ILLUMINATING ENGINEERING

OCTOBER 1953

◆

Evaluations and Developments in Street Lighting
A Rating Guide for Fluorescent Luminaires
Brightness Meter Design Characteristics
Redesigning a Period Chandelier
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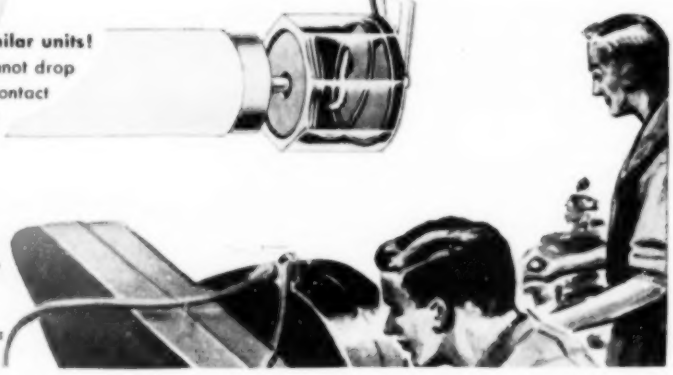

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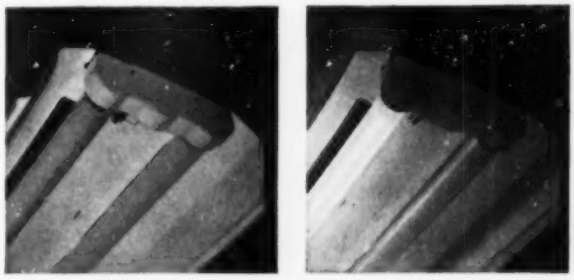

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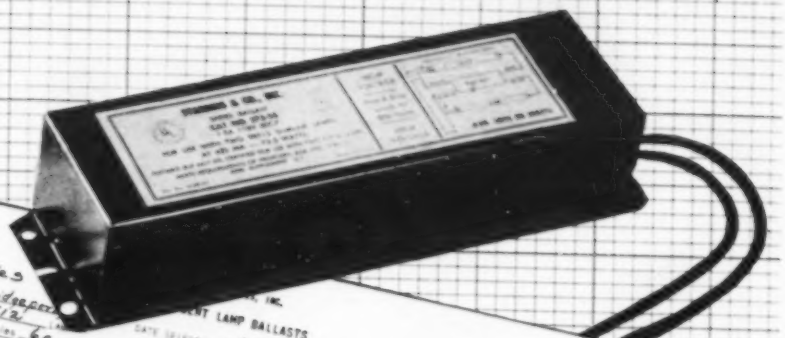

a typical ETL test on the Starring 275-SS fluorescent ballast

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ILLUMINATING ENGINEERING

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1953

Vol. XLVIII
No. 10

A. Homer Manwaring—President, I.E.S. 505

Technique for Explosion-Proof Lighting — John M. Adams 506

Street Lighting Photocell Control Calibration Cabinet — W. N. Lindblad and L. C. Edwards 509

Modern Lighting for Renaissance Architecture — J. F. Gunther and S. D. Snook 513

Light and Night Traffic Accidents — David M. Baldwin 515

Instrument for the Evaluation of Night Visibility on Highways — A. E. Simmons and D. M. Finch 517

Design Characteristics of a Photo-Electric Brightness Meter — Karl Freund 524

I.E.S. Lighting Data Sheet—Series XVIII
Lighting a Cotton Classing Room (6-21) 527

Some Observations of Fluorescent Street Lighting Here and Abroad — Philip H. Houser 529

The Development of Highway Lighting in Metropolitan Chicago and Northern Illinois — R. J. Seitz and E. M. Prims 534

Comparative Rating Guide for Fluorescent Lighting Fixtures — L. V. James 539

Also: Daylight and Mercury in High-Bay Area, 512; Troffers in a Camouflage Ceiling, 514; Varied Lighting System for Multi-Purpose Room, 523; Fluorescents in an Amusement Park, 533.

TELECAST—Lighting News of Current Interest 6A
It Seems to Me, 11A; Obituaries, 15A; Books and Pamphlets, 15A; About People, 27A.

I.E.S. Council and Officers for 1953-1954 19A

I.E.S. Section and Chapter Chairmen for 1953-1954 20A

National and Local Officers, I.E.S. 22A

I.E.S. Publications 4A, 36A

Index to Advertisers 37A

Sustaining Members—for latest listing of Sustaining Members, refer to September 1953 issue of ILLUMINATING ENGINEERING.

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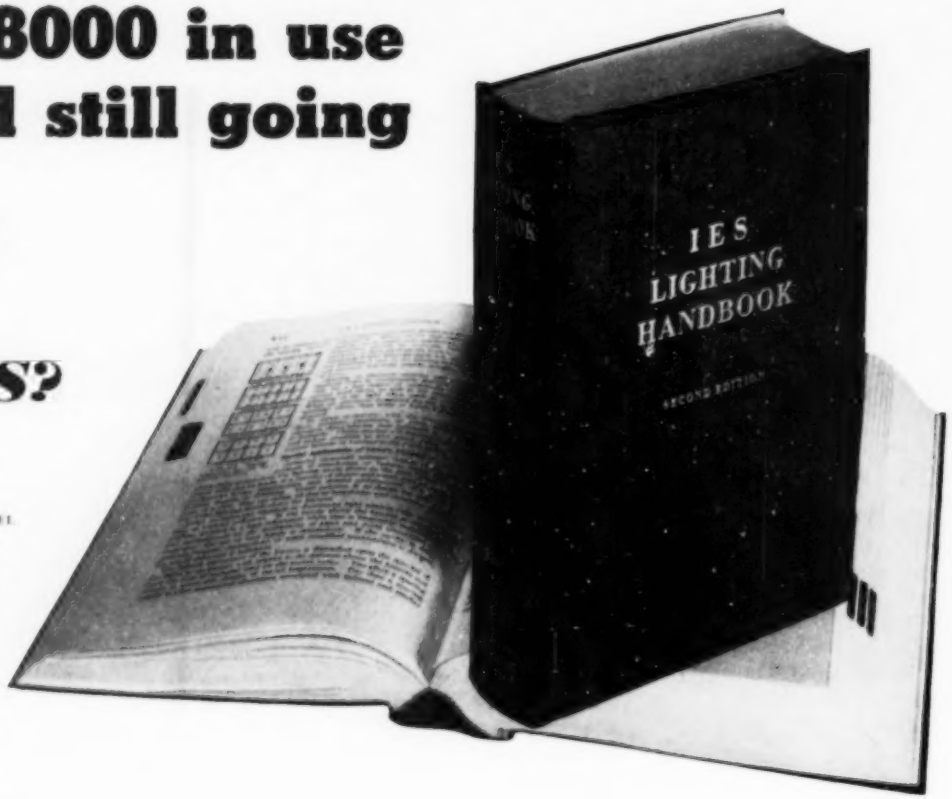

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Albert Homer Manwaring, President

Illuminating Engineering Society—1953-1954

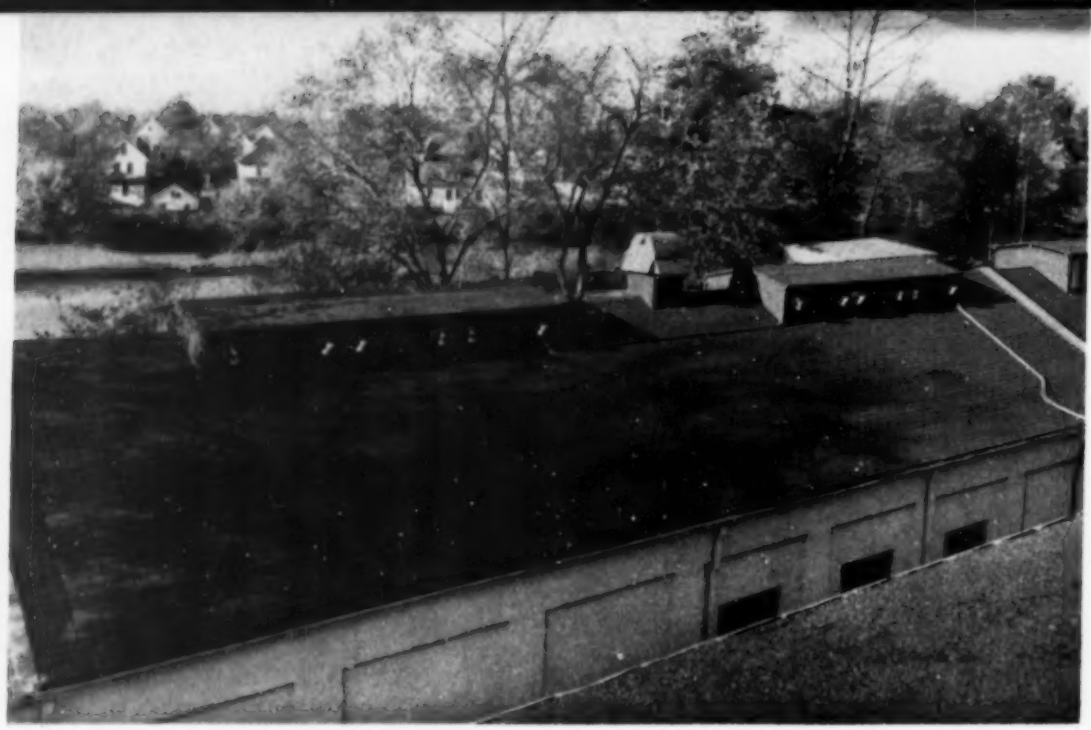
DURING the administration of an I.E.S. President, literally thousands of the Society's members meet him in person, hear his views and aims for the Society's growth, and entertain him as their Section's and Region's guest. On these occasions, like the nation's top executive, he is frequently introduced as simply "The President of the Illuminating Engineering Society." May we herewith "introduce" him in more detail.

Our current President, A. Homer Manwaring, is the youngest man to achieve the presidency of the Illuminating Engineering Society. At forty-one, he is a recognized top executive in his industry and brings to his I.E.S. Administration a high order of experience gained in the lighting *business* as well as Society affairs and leading organizations associated with the lighting industry. Mr. Manwaring is Executive Vice-President of the Philadelphia Electrical and Manufacturing Company (Pemco), rising to that position from Cadet Engineer with Philadelphia Electric Company (1934) through Sales Engineer for Pemco (1937) and Manager of Sales and Engineering (1940). In 1942, at the age of 30, he was named Executive Vice-President and General Manager, and a member of his company's Board of Directors.

Mr. Manwaring's service to I.E.S. is equally distinguished. Since joining the Society in 1934, he has held many offices, both at the national level and in the Philadelphia Section. He has served as Chairman of the Section, 1945-46, and as a member of the Street and Highway Lighting Committee for many years. In 1948-49 he was elected General Secretary of I.E.S. and a member of Council, and in 1951-52 was elected Vice-President.

The new President is also an active member of NEMA, particularly as a member of the Technical Committee of their Street Lighting Section. At present he is serving on the Street and Highway Lighting Industry Advisory Committee NPA. Mr. Manwaring was graduated from Penn State College (Industrial Engineering B.S. degree) in 1934. From 1934 to 1936 he served as a lieutenant in the United States Marine Corps, and was a Cadet Engineer with the Philadelphia utility. In 1942-1944 he served as Secretary for the Philadelphia War Production Pool.

Mr. Manwaring is frequently accompanied at I.E.S. affairs by his very charming wife Esther, his two young sons Albert and John and his daughter Barbara.



Exterior application of R-40 lamps in this distilling plant developed a

Technique for Explosion-Proof Lighting

By JOHN M. ADAMS

A successful technique is described for creating explosion-proof lighting in an area where regular explosion-proof equipment was not practicable.

OUT OF THE blue, you might say, Fritzsche Brothers plant in Clifton, New Jersey, was informed by the New Jersey Department of Labor that their distilling and processing plant had been classified as a hazardous location. They must take whatever steps were necessary, said the edict, to install a lighting system which would pass the requirements of the National Electrical Code, Class I-D. In studying this problem with them, we found that several factors ruled out the first explosion-proof layout we naturally prescribed.

The building is used for the manufacture of citrus oil concentrates, the processing of essential oils and the processing of essential resins for the flavor industry. Normal manpower complement seldom exceeds three men. The work performed is not a difficult seeing task and the recommended minimum is 10 footcandles.

Approximately 20 per cent of the wall area is taken up by windows, and the clerestory improved daylighting conditions. The interior of the building is painted completely with a flat white of approximately 75 per cent reflectance. Only one shift is in operation, and future planning does not include a change in this operating schedule. To be very practical, artificial lighting at all is only necessary during winter afternoons and evenings and on extremely dark days. But at such times it is very essential. Some of the products manufactured are valued at $200 a pound. Breakage of say a 10-gallon demijohn of essential oil would represent a loss of about $50,000.

How then, to inexpensively (an important factor) satisfy Class I-D requirements. Further study of the problem indicated that most of the electric

This installation won first prize in the contest for "My Most Interesting Lighting Job" conducted by the New York Section, and second prize in the Northeastern Regional contest. Mr. Adams is lighting representative for the Public Service Electric and Gas Co., Passaic, New Jersey.

Figure 2, above, is a night-time shot of the plant area, illuminated to 11 footcandles by means of twenty-four 300-watt R-40 lamps mounted outside the clerestory windows, with all light reflected from the walls. Figure 3, at right, is a "before" picture of the same area.

motors in use are for the purpose of evacuation. It is the intention of the company to replace these motors with steam jet evacuators, and any motors still necessary for portable mixers are to be explosion-proof. If then, most of the wiring for power is removed, why not remove the wiring for lighting and also that for the few remaining portable units? A check with the Labor Department and the Fire Insurance Rating Organization of New Jersey confirmed that the placement of lamps in open atmosphere, aimed through the windows, would meet the requirements of an explosion-proof system.

An experimental installation was made in which floodlights mounted on brackets at the top of the windows were aimed at the opposite wall area. This approach to the problem verified the fact that the principle was practical. It was not acceptable, however, since the glare from the 1500-watt lamps used was unbearable. It was at this point we thought of using R-40 lamps aimed through the windows of the clerestory toward the opposite wall.

Since some of the windows in the clerestory could and would be opened for ventilation, only six windows in each section could be used for lighting without resorting to structural changes. Thus, 24 windows were available.

The next question was how many lamps to use. No information was available for this type of installation and a laboratory test to provide coefficients of utilization was out of the question. Three methods were used to determine the number and size of lamps to be used, and in each method numerous assumptions were made.

First it was arbitrarily assumed that the losses in exterior lighting would be such that an increase of two-thirds more power would be required. Thus five watts per square foot would necessitate twenty-four 300-watt R-40 lamps. The lumens required were also computed using the Coefficient of Utilization for a known units with a wide distribution and a greater outer candlepower than that developed perpendicular to the lens of the unit. With this figure of total lumens, correcting for window

efficiency, it was found that a total of twenty-eight 300-watt R-40 lamps was required.

A third approach, based on several assumptions, was then worked out, which checked out approximately with the other solutions. It was assumed that the window area of 324 square feet would reduce the reflection factor of the wall by 324/1600 or 20 per cent, disregarding the lumens which would be reflected by the glass. Another assumption was that only 60 per cent of the light striking the wall would be reflected towards the floor and that the remaining 40 per cent would be absorbed in the upper levels of the room. The spill light which, as a direct component, was relatively minute, was also disregarded. Thus, the average footcandles desired multiplied by the area and divided by the corrected reflectance factor and the percentage of downward light produces the total lumens necessary in the building interior. Assumed transmission factor, dirt factor and loss factor total 30 per cent and the total experior lumens required by this method could be provided by twenty-six 300-watt R-40 lamps.

Thus, by arbitrary assumption, similar equipment and logical assumptions the average number of 300-watt R-40 lamps required to provide an average of 10 footcandles was 26. There was room for exactly 24 lamps without carpentry. Twenty-four lamps were installed. Still, if all of the computations and assumptions were correct, who could distinguish a difference of 0.8 footcandles? The footcandle levels obtained with twenty-four 300-watt lamps are 11 footcandles in approximately 10-foot widths by the wall on either side of the building, and six footcandles in the 10-foot strip down the center. Since the walls and ceiling become the source of light, the brightness of all surfaces except that of the floor fall within the 10 to 1 ratio. (Ceiling brightness over desk is 2.5 footlamberts; wall brightness over desk 8.3 footlamberts; work on desk 8.0 footlamberts). By inserting twenty-four 500-watt reflector lamps the levels climb to 17 footcandles in the 10-foot strips on either size, and 10 footcandles in the center.

The exterior view photograph shows the lamps and brackets as they were actually installed. As can be seen in the photograph, the conduit runs up the wall from a weather-proof box and is separated into four circuits. The expected one-shift operation however, was not dependable and the system was wired to carry thirty-two 500-watt R-40 lamps with two extra circuits remaining in the control box. It is fortunate that this policy was followed, for at the present time there are now two full shifts in operation. With the advent of the second shift, the installation has been modified slightly. Two lamps are to be installed and windows made in the vertical side of each end of each clerestory. This modification will provide a much higher direct component and should give a more nearly even distribution of light on the floor area.

At the present time Fritzsche Brothers are contemplating a new building. They have asked the lighting engineers to work in conjunction with the Architect to design the new building specifically for this type of lighting. They have also requested that a second existing building be fitted in the same manner. Is it possible then for the Architect to design the building for lighting in hazardous areas instead of designing the lighting to fit the requirements of the building as well as the purpose for which it is used?

I.E.S. Gold Medal Nominations

The deadline for nominations for the I.E.S. Gold Medal Award is January 1. All members of I.E.S. are invited to make nominations for consideration by the Medal Award Committee.

The Gold Medal — the Society's highest honor — is awarded for the purpose of giving recognition to meritorious achievement which has conspicuously furthered the profession, art or knowledge of illuminating engineering.

Candidates may be nominated at any time by any member of the Society, by presenting to the General Secretary at Society Headquarters the name of the individual whose accomplishments are deemed worthy of such recognition. Candidates need not be members of I.E.S. and their achievements may be in the fields of engineering, design, applied illumination, optics, ophthalmology, lighting research, education, or administration and management.

Nominations and records on file from previous years are reconsidered along with new nominations. But each new nomination must be delivered to Headquarters Office by January 1 to be eligible for this year's award.

Street Lighting Photocell Control Calibration Cabinet

By W. N. LINDBLAD
L. C. EDWARDS

I. Introduction

IN THE PAST two years a large Northern California utility company has initiated an extensive program toward the modernization of its street lighting controls. With the development of modern and reliable light sensitive devices for the control of switching operations it is felt that these devices can reliably and economically replace the previous manual and time clock operations. In connection with this program a simple photocell calibration cabinet was developed for operation by non-technical personnel with a minimum of instruction. This cabinet is described below.

The territory served covers Central and Northern California, extending for a distance of approximately 495 miles and between 35 and 41 degrees north latitude and over 5.5 degrees of longitude. In such an extended territory as this, one of the first concerns involving the utilization of light sensitive controls was the possibility of variation in burning hours for the extreme north and south areas because of the different sunset-sunrise characteristics.

Accordingly several photo-controls, manufactured by four different firms, were installed at various locations on the system as part of a study of control operation. They were equipped with elapsed time meters for a continuous measure of lamp burning hours and were calibrated or adjusted to a turn-on value of 1.5 footcandles before installation. The value of calibration was originally decided upon after a careful consideration by the lighting engineers in charge of the study. The correctness of this value is now confirmed after approximately three years of operations during which the average burning hours of the survey installation have deviated only approximately 0.6 per cent from the scheduled 4100 hours.

The controls approved for company standards are of the photo-tube type. They comprise two or three electronic tubes, an electronic circuit of many components, and small relays. These devices are so compact that they may be housed in a small watthour meter socket or equivalent volume, and the survey tests have proven that they can be very reliable. Some have been in continuous operation for approximately three years with no attention and no replacement of tubes or components whatsoever. Others have given trouble and have had to be repaired and adjusted.

All units require, of course, an adjustment or calibration to the desired turn-on footcandle value, and it is desirable to give new units a thorough inspection of the relay contacts and moving parts as well, thus contributing greatly to successful operation. After a period of time there develops a maintenance problem, the electronic tubes will fail, contact trouble will develop, components may fail, and in general there will be need to re-condition and re-calibrate units.

In the study mentioned above, this re-conditioning and calibrating was done in the general engineering laboratory of the company during the first couple of years while the devices were being tried out. However, after the devices were generally installed throughout the system it became apparent that a better method would be to have each of the thirteen divisions of the system handle and be responsible for the operation of its photo-controls. The present policy is, therefore, to provide each division with the necessary equipment to maintain and calibrate its respective controls. Therefore, a footcandle calibrating device has been developed and distributed to the various divisions, so that a standardized procedure will be established throughout the area. It was necessary for the calibrating device to be simply operated and adaptable to all types of photo-electric controls. Reports from the field indicate that these aims have been satisfactorily accomplished.

II. Design of Suitable Equipment

The type of calibrating device and method of operation decided upon is not greatly different from some of the cabinets and light tunnels in use elsewhere. However, the test cabinet incorporates some features that we believe make for simplicity

A paper presented at the National Technical Conference of the Illuminating Engineering Society, September 14-17, 1953, New York, N. Y. AUTHORS: Engineering Laboratory, Pacific Gas and Electric Co., San Francisco, Calif.

Figure 1. Street lighting photocell control calibration cabinet.

and stable operation. Fig. 1 shows an exterior view of the device with a control mounted for calibration. The method in brief is to expose a control unit to the 1.5-footcandle illumination level of the interior of the calibrating cabinet and then make an adjustment of the units potentiometer until it operates to switch "on." This operation is indicated by the lighting of a small lamp simulating a controlled street light. No provision is made for determining the switch "off" value, and there is no adjustment for it in the control units. However, tests indicate that with an "on" value of 1.5 ft-c the average "off" value is approximately 3.5 ft-c. The calibrating cabinet is designed for electric operation from a standard 120-volt service. The calibrating illumination is obtained from a 10-watt daylight mazda lamp. Construction and operation features follow:

Cabinet: In essence, the calibrating cabinet consists of a wooden cubicle illuminated on the inside to the desired footcandle level by projecting light in through an aperture in one side. The photocontrol to be calibrated is subjected to this illumination at an adjacent aperture on the same side. The unit therefore is exposed to the reflected light from the five other interior surfaces of the cabinet with none directly from the source. This form was accepted as most nearly approaching the photometric sphere in the simplest practical form. The dimensions are two feet on a side. The interior is painted a flat white color and the top is removable for cleaning and maintenance. All components are located on the exterior of the cabinet with the exception of one lamp that is utilized to simulate a bright daytime condition.

When arranged for calibration a control is placed in the metal bracket as depicted in Fig. 1. This places the unit's photoelectric tube directly in the illumination aperture of the cabinet. A dark cloth curtain is provided that covers both top and front side of the bracket to exclude external light. It is fastened at the top and is rolled up when not in use as shown. Holes are provided at suitable locations in the cloth for the insertion of a screw driver to make potentiometer adjustments. There are several of these holes provided as each different make of photo-electric control device has its adjustment located in a different place, some in the top and others in the back.

Mounting Holders: There were three types of control units encountered. They required holders to mount them properly in the bracket with the phototube in the aperture. The holders provided are shown in Fig. 2. They are complete with base, contact socket, glass cover, and a length of control plug-in cable. All calibrating is done with the controls in a normal condition, that is, the unit in its typical socket or housing, and glass cover in place. Holes are provided either through the glass test covers or through the back of the metal sockets for screwdriver adjustments. The height of the holders is such that the photo-electric tubes are at the correct height in the aperture.

Electric Circuit: The circuit diagram is shown in Fig. 3. Four lamps are included in the circuit, two of which have been previously mentioned. The four are: pilot light which indicates when the cabinet is energized; a 7½-watt white bulb which simulates the controlled street lamp shown mounted externally on the control panel; a 40-watt internal lamp which provides a high level of 150 footcandles to simulate a value of daylight; and a 10-watt type S-14 blue mazda daylight clear bulb which provides the calibrating illumination.

The illumination of the cabinet can be switched to three different conditions, namely, Dark — simulating night time; Calibrate — wherein the cali-

Figure 2. Calibrating holders for photocells.

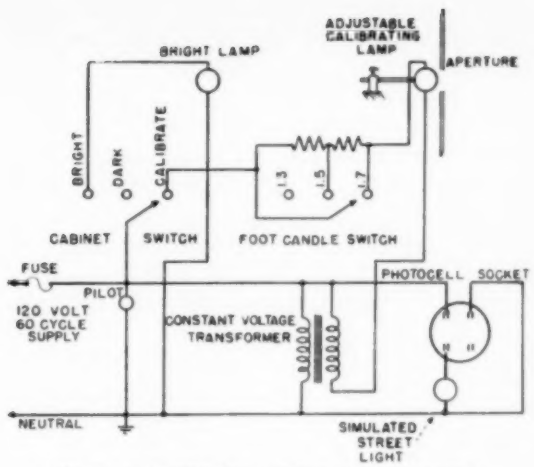


Figure 3. Calibration cabinet circuit diagram.

brating level of 1.5 footcandles is obtained; and Bright — wherein an intense level of 150 footcandles is obtained to simulate daytime condition. These conditions are obtained by means of the "cabinet condition switch." The Calibrate condition is further adjustable by means of an additional three-position switch. The 1.5-footcandle level can be altered to either 15 per cent higher or lower, 1.3 and 1.7 footcandles respectively. These two values are helpful tolerance limits when calibrating. For example, when a control is adjusted to switch "on" at 1.5 ft-c is should not go on at 1.7, and if a supposedly correctly calibrated unit fails to switch "on" at 1.5 it is considered satisfactory if it does go "on" at the lower value of 1.3 ft-c.

Calibrating Lamp: The type S-14, 10-watt, 120-volt, blue daylight clear lamp was considered to be most satisfactory because of its availability and size, and tests indicated its Kelvin temperature to be slightly higher than the other standard bulbs. The potential supplied to the lamp is maintained at a constant value by means of a constant voltage transformer, to eliminate errors due to fluctuations in voltage.

The normal illumination level of 1.5 ft-c is obtained essentially by adjusting the position of the blue daylight lamp in the lamp aperture. This condition is determined by measuring the illumination in the control aperture by means of a footcandle meter. The tolerance values of 1.3 and 1.7 are obtained by increasing and reducing resistance in series with the lamp to make potential changes of approximately plus or minus 3 volts.

III. Instructions for Use

A compilation of test procedures and calibration instructions has been arranged for the operators of the devices in order that the method will be standardized in general throughout the system. A copy of the instructions is as follows:

(a) Unit Condition — A photo-electric relay for calibration must of course be in good operating condition; all tubes, contacts, and circuits should be in good order.

(b) Pre-heating — To energize the cabinet plug into 120-volt, 60-cycle service. The control unit to be calibrated should be energized for a period of one-half hour immediately previous to testing to allow the components of the electric circuit to attain operating temperature. This can be accomplished by mounting in a holder and plugging into the cable receptacle, or if there are many units to calibrate it is advisable to provide extra sockets for the preliminary heating.

(c) Preliminary Operating Test — The unit is mounted in socket holder complete with glass cover, the entire assembly placed in the bracket, dark cloth adjusted into place and held by the side springs, and the three-conductor cable plugged into the cable receptacle. Switch CABINET CONDITION to DARK. Under this condition the unit should operate and the simulated street light be switched "ON." Then switch to BRIGHT and the unit should switch "OFF." This procedure indicates that the unit is in proper operating condition and suitable for final calibration.

(d) Calibrating — Switch from "Bright" light to 1.5 ft-c.

1. If unit switches "on" switch back to "bright" light then to 1.7 ft-c. If unit now stays "off" it can be considered as being good.
2. If unit does not switch "on" switch back to "bright" light and to 1.3 ft-c. If unit switches "on" it can be considered as being good.
3. If unit does not operate as shown above it must be "adjusted" as shown in (e) below.

(e) Adjustment:

1. Turn adjustment of rotary potentiometer resistance to extreme "low," "dark," or "late" position.
2. Switch "cabinet condition" to "bright," then to "calibrating" 1.5 ft-c, then slowly turn unit adjustment away from "low" position until the unit switches "on"; this is the calibrated position. (The turning operation should be made very slowly, a small angle of 2 degrees per 10 seconds. It should thus require two or three minutes to make this adjustment. The units have a time delay

feature intentionally incorporated in the circuit to preclude an "on" operation with intermittent flashes of light.)

3. After above adjustment repeat Test (d) above for a confirmation test.

General Remarks: Measurements made of both twilight and dawn light intensity indicate that when plotted with time, one is the mirror image of the other. The curves are of an exponential form and the values of illumination at which the controls switch "on" and "off" are in the knees of the curves. On the twilight curve at the 1.5 ft-c value the rate of change of illumination is approximately 0.35 footcandles per minute. At dawn, because of the shape of the curve, the time required to increase from the previous "on" value to the switch "off" value of 3.5 ft-c is approximately four minutes. This means that there is an average delay in the controls switching off in the morning of four minutes. The total average for a year is thus 1460 minutes overburning. This value is approximately 0.6 per cent of the scheduled burning hours and confirms the value obtained by the elapsed time meters.

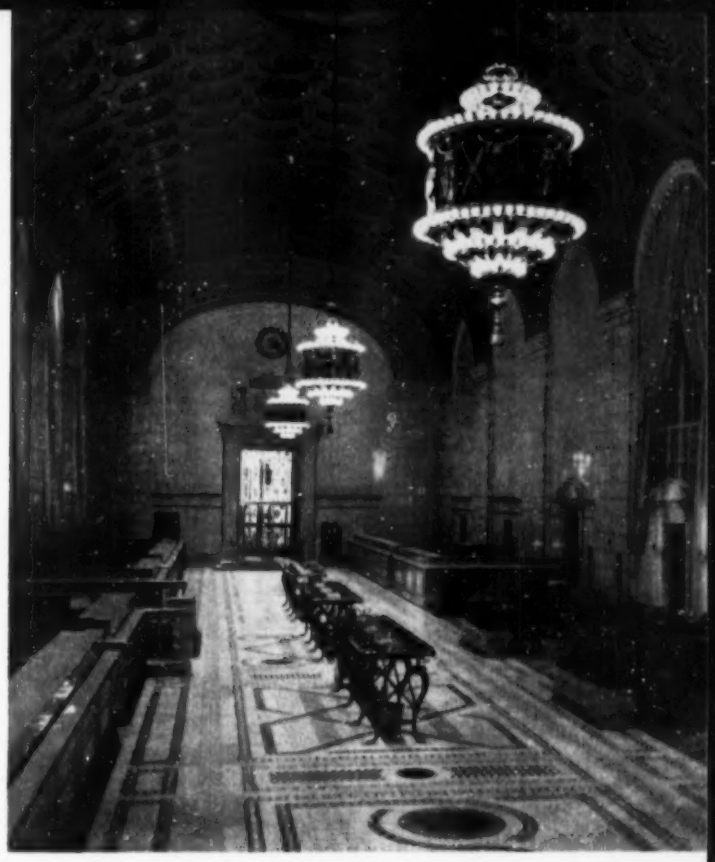
Daylight and Mercury For High-Bay Area

This 325 x 75-foot high-bay forge and machine shop, at Babcock-Wilcox Co., Barberton, Ohio, is in use 24 hours a day, for machining of large hollow forgings and the preparation of ingots for forging operations. Large skylight and window areas provide daylight adequate on some days, and the lighting installation provides an average of 25 footcandles for use at night and on dark days. Mounted on 25-foot centers at a height of 52 feet, are high-bay Alzak aluminum luminaires containing 1000-watt C-H12 color corrected mercury lamps. Lamps are operated from single-lamp high-power-factor ballasts on 230 volts, with ballast loss approximately 85 watts per ballast. Relamping and cleaning is accomplished from the top of a traveling crane during daylight hours when the lamps are de-energized. Lighting data submitted by Les Hessoun, Moock Electric Supply Co., Akron, Ohio. ***Photo courtesy Westinghouse Electric Corp.***

Modern Lighting for Renaissance Architecture

By J. F. GUNTHER
S. D. SNOOK

This installation won second prize in the contest for "My Most Interesting Lighting Job" conducted by the New York Section, I.E.S. Mr. Gunther and Mr. Snook are lighting representatives with Consolidated Edison Company of New York, Inc.



Before (below) and After (above).

WITH modern structures, modern lighting can be a matter of proper design, engineering, and choice. The application of good lighting principles to older structures, however, calls for considerable ingenuity as well. In relighting the banking floor of a Brooklyn branch of Manufacturers Trust Company, we were faced with an old building erected in 1916. Further, with an interior inspired by Italian Renaissance architecture in the best 14th Century tradition.

The enormous, suspended bronze chandeliers with which this interior was illuminated suited the architectural style very well. The bare 25-watt lamps with which they were equipped however, delivered a meagre six footcandles—and plenty of glare. Modern practice called for 35 to 40 footcandles of general illumination, with 75 to 100 locally on the tellers counters.

The second horn to the dilemma was the preservation of style and architectural detail in the lighting equipment. For the tellers counters, concealed equipment was the answer. For the chandeliers, so suitable aesthetically, it was decided to provide the illusion that they were the only apparent source of light, concealing the real sources in the ceiling and under the counters. It was, of course, necessary to reduce their brightness to within the comfort zone. To achieve this illusion, in the most practical manner, downlights were located above octagonal ceiling coffers in two rows of 29 units each. A metal plate with a 6-inch aperture and decorated to the design of the present ceiling treatment was installed on the underside of the ceiling, and fastened to the structure above. It not only served to remove the weight of the downlight from the ceiling but it braced the plaster ceiling by transferring some of the weight to the structural members. The lighting unit has a cut-off of 45°

and is baffled to avoid a scalloped effect on the walls. Each downlight is equipped with a 750-watt, T-24 bipost lamp. The ceiling height at the downlight aperture is 39 feet.

The tellers counters and wall counters are equipped with troffers installed end to end and containing two rows of T-6 fluorescent lamps operating at 300 ma. These units were custom built and are installed as an integral part of the counters. They are equipped with porcelain enamel reflectors and louvered glass panels to shield the lamps. Too large to be removed from the building, the three chandeliers suspended from the vaulted ceiling were cleaned and altered on the job. Low brightness A-17, 15-watt inside ivory finished lamps operating at approximately 10 volts under-voltage repiaced the 25-watt inside frosted lamps which had been operated at normal voltage in each chandelier.

In our original lighting design, we had not recommended lighting the ceiling since it was to be cleaned, and the very light floor and walls would redirect enough light to brighten it. These plans changed however, when it was found that the ceiling would be damaged by cleaning. Footlambert readings showed its brightness very low compared with the side walls. It was necessary to literally "clean" the ceiling with light, raising the brightness from an original 0.5 footlambert to an average of four footlamberts. This was done as follows:

A metal pan was installed in the top of each chandelier in sections, and eight 300-watt R-40 floodlamps were provided for the ceiling lighting. Four 150-watt PAR, floodlamps were located at the outer rim of the pan. The PAR lamp was used for the high side wall lighting at the spring line, inasmuch as its beam spread was more compact than that of the R-40 lamp. This resulted in the PAR floodlamp leading the brightness of the walls from 5.5 footlamberts into the zenith of the arch, which is 3 footlamberts.

Results

Illumination levels and brightness readings are now as follows: Ceiling brightness, 3 to 4 footlamberts. Wall brightness, 5 to 6 footlamberts. Illumination on counter areas, 75 to 100 footcandles maintained. General lighting, 35 to 40 footcandles maintained.

The "after" picture illustrates the most important result, namely the illusion that the chandeliers appear to be the only light source. The downlights are quite inconspicuous; there is no sharp cutoff on the side walls. The 125-volt inside ivory coat of the lamps in the chandeliers, operated under voltage, emit a golden tan color and blend into the background areas. They match the marble walls which have been cleaned and polished into the original light buff. Matching these lamps to the surround heightens the illusion that they are the main light source.

Retaining the architectural decor with major alterations is somewhat rare, we think, but this job shows how a definite period interior can be enhanced by a well-planned lighting system.

Troffers in a Camouflage Ceiling

In order to hide beams, pipes and telephone conduit, an acoustical ceiling was installed 17 inches below the concrete slab in the Utica, N. Y. office of Niagara Mohawk Power Corp. Flush-mounted in this ceiling, on tee-bars and self-aligning hangers, are five rows of 3-lamp troffers with prismatic lenses, with 17 units in each row. Lamps are 40-watt standard cool white. Illumination level after 10 weeks' operation averaged 65 ft-c. Designed by J. C. Bannigan, Lighting Representative with Niagara Mohawk, this installation was a runner-up in the Central New York Section's contest for "My Most Interesting Lighting Job."

Light and Night Traffic Accidents

By DAVID M. BALDWIN

THIRTY-EIGHT thousand men, women and children were killed during 1952 in motor vehicle traffic accidents in the United States. This is the largest total since 1941, when 39,969 persons died.

It is perhaps a minor satisfaction to know that on a rate basis 1952 was the best year ever recorded. In 1925, when the calculation was first possible, the mileage death rate in this country was 17.9 deaths per 100,000,000 vehicle miles. This has decreased quite steadily to the current low point of 7.3, recorded in 1952. In 1941, when deaths were only slightly higher than last year, the mileage death rate was 12.0 per 100,000,000 vehicle miles.

Slightly over 70 per cent of last year's traffic deaths occurred in rural areas outside cities and towns. The total is estimated at 27,000 in rural areas and 11,000 in urban areas. It is interesting to compare this with 1941, when the rural total was just under 26,000 and the city total was slightly over 14,000. The percentage of the total deaths which was reported for rural areas has remained almost constant, however, for the last four years, which perhaps indicates that the trend toward an increasingly large rural death proportion has been halted.

Of primary importance for this discussion, however, is the fact that 45 per cent of the total deaths during 1952 occurred during hours of daylight and 55 per cent during hours of darkness (including dusk and dawn). The year before, 1951, saw 56 per cent of the total occurring during hours of darkness, while in 1941, 58 per cent of the total were during night hours. This trend is hardly great enough to arouse either gratification or concern.

Of some importance in this matter is the fact that while 55 per cent of fatal accidents occurred during hours of darkness, only 38 per cent of all accidents occurred during night hours. Thus the severity of night accidents would appear to be considerably greater than that for daytime accidents.

It is also interesting to note that when urban and rural accidents are considered separately, the nighttime percentages vary slightly. For urban accidents, 59 per cent of the fatals occurred during hours of darkness, while in rural areas 53 per cent were nighttime accidents.

Both of these factors—that of increased severity for night accidents and the higher night percentage in urban areas compared with rural areas—can be related to pedestrian accident experience. Pedestrian accidents account for about half the urban death total in contrast with the situation in rural areas in which pedestrian deaths are but one-seventh of the total. Particularly in urban areas, pedestrian deaths are more frequent during hours of darkness.

Looking at the problem in another fashion, and taking into account relative travel during hours of daylight and hours of darkness, the night accident problem becomes even more severe. Based on the best estimates available, the mileage death rate at night is about three times the rate during hours of daylight. Thus it is safe to say that one's chances of being involved in a fatal traffic accident at night are three times as great as during the daytime. The rate at night is estimated at about fourteen deaths per 100,000,000 vehicle miles and for daylight hours about five deaths per 100,000,000 vehicle miles. This same proportion holds fairly well for urban and rural experience considered separately.

All of these statistics point clearly to the fact that nighttime creates special problems for drivers. There must therefore be some differences in day and night driving—the most obvious of which is the difference in visibility. Other factors which may contribute include fatigue, alcohol, and possibly differences in drivers themselves.

Let us examine these factors in reverse order, starting with the possible differences in drivers themselves. What had earlier been supposition in this area was recently confirmed by a study made by Dr. A. R. Lauer of Iowa State College. He sampled drivers on Iowa highways every hour of the day, studying nearly 5,000 cases during the period from fall to early spring.

It was found that speed of travel and age were inversely related at times when traffic flow was light. For instance, on rural highways between midnight and 7:00 in the morning, 51 per cent of drivers were in the 20 to 29 year age group, most of them 24 and below. The 20 to 29 age group

A paper presented at the National Technical Conference of the Illuminating Engineering Society, September 14-17, 1953, New York, N. Y. AUTHOR: Director, Traffic Division, National Safety Council, Chicago, Ill.

constituted only 23 per cent of the daylight traffic and 24 per cent of the traffic from 5:00 p.m. until midnight.

Dr. Lauer reported evidence of a group of drivers (constituting about 10 per cent of the 20 to 24 year age group) flagrantly and dangerously violating safety rules from midnight to 4:00 a.m. He found only rare cases of excessive speed among other age groups or at other times of the day. The mean speed of all men observed was 47.6 miles an hour at an average age of 36.2. The mean speed of drivers between midnight and 5:00 a.m. was 50.6 and the average age was 29.3

All of this points to the fact that particularly after midnight there is probably more reckless operation of motor vehicles than at other hours of the day, at least in proportion to the total amount of traffic. It would not be surprising therefore to find a proportionately higher accident experience.

It is extremely difficult to pin down any accurate information on fatigue. Accidents in which the driver is reported as "apparently asleep" are causing considerable concern, however, on facilities like the Pennsylvania Turnpike and the New Jersey Turnpike. These accidents seem to occur more frequently during hours of darkness, or at times when most human systems are accustomed to sleep. No real quantitative measures are available, however, to estimate the importance of this problem nationwide.

There is evidence to indicate that the incidence of alcohol among drivers reaches a peak during hours of darkness. In a famous study made more than 15 years ago in Evanston, Illinois and reported in the *Journal of the American Medical Association*, very definite peaks were noted in the time distribution curve for drivers under the influence, both non-accident cases and accident cases.

Subsequent studies by the Michigan State Police and other traffic accident records agencies have identified similar peaks. In Michigan, for instance, 77 per cent of the accidents involving drinking drivers occurred during hours of darkness. A report on this study, which was made in 1947, includes this sentence: "Since most drinking and subsequent driving takes place during the evening and nighttime hours, the drinking driver is probably responsible for a substantial part of the increased accident rate during hours of darkness."

It seems clear, on the basis of this and other evidence, that there are a number of factors responsible for the increased accident rate at night. Different drivers, sometimes fatigued or even asleep, and sometimes under the influence of intoxicating liquor, all contribute to this experience. In addition, there is the very large and obvious factor of reduced visibility. The best evidence that the change in visibility contributes to increased night accident experience lies in the many examples of accident reduction following efforts to increase night illumination. Street lighting improvements have almost universally been followed by fewer accidents and deaths. Perhaps even drunken drivers are better drivers when they can see where they are going.

This experience of accident reduction following the installation of adequate street lighting is well-known. Detroit's experience has been established over a period of many years. Milwaukee, Kansas City, and many others have set substantial records in this area. Chicago is well on its way. The evidence is clear that adequately lighted streets bring about reductions in traffic accidents.

It is obviously impossible to attempt to assign any relative values to the influence exerted on the night accident rate by any of the factors mentioned. We cannot, for instance, say that alcohol is a ten per cent factor, fatigue a five per cent factor, reduced visibility a fifty per cent factor, and so on. We do believe that all are factors and that any well-rounded accident prevention program must recognize that all are factors. Looking at the matter from that standpoint, the question then becomes one of what can be done about the situation.

Certainly the most direct and obvious approach is that of providing improved street lighting. None of the other problems offers an opportunity for such a direct approach toward a solution. Every city should examine critically its present street lighting program in comparison with I.E.S. standards and embark upon a program to bring lighting on its high-accident streets up to par. We know the results will be evident in a lower accident rate, in longer life and greater happiness for the citizens of the community.

An Instrument for the Evaluation Of Night Visibility on Highways

By A. E. SIMMONS
D. M. FINCH

THE APPRAISAL of a highway lighting installation is most difficult at the present time for there is no straightforward technique available to arrive at an objective evaluation of a given lighting job. It is the object of this paper to describe one technique that appears to have merit for the evaluation of actual lighting installations. If the technique proves as useful for field work as the preliminary studies indicate, it may lead to the inclusion of roadway brightness values in the requirements of the design.

The development work described herein has been conducted under the sponsorship of the I.E.S. Research Fund and the I.T.T.E. of the University of California. Work in the general field of night-visibility on highways has been a part of the University research program for the past several years. In August 1952 a grant from the I.E.S. Research Fund was made available for further studies. This paper is an interim report of progress as well as a discussion of a visibility measurement technique.

The basic design conditions for street and highway lighting are concisely stated in the American Standard Practice for Street and Highway Lighting, 1953 and the I.E.S. Lighting Handbook, 1952. As stated in these references, the objective of street and highway lighting is to provide adequate pavement brightness with good uniformity and appropriate illumination of adjacent areas, together with reasonable freedom from glare.

The factors that directly influence night-visibility are:

1. The actual object brightness on or near the roadway.
2. The average brightness of the immediate background of the object — (within a 3- to 5-degree angle).
3. The brightness pattern of the surround within the principal visual field (approximately 60-degree angle).
4. The contrast between the object and its immediate background.
5. The ratio of brightnesses within the principal visual field.
6. The size and shape of the object and its identifying detail.
7. Motion of the object and observer.
8. Time available for seeing.
9. Glare caused by extremely bright sources anywhere in the visual field.

The above factors, although recognized and defined in the present recommended practices, are not used directly in highway lighting layout or evaluation work, probably because of the limited amount of information on the reflection characteristics of surfaces and the methods of calculating brightness. The importance of the roadway brightness is gradually being recognized and will probably be given proper weighting as soon as procedures are readily available for brightness calculations. Practically all street and highway lighting layouts are now made upon the basis of *average* horizontal illumination even though it is known that the illumination is not directly related to roadway or object brightness. Several recent articles have appeared in foreign publications[1] indicating that roadway brightness calculations are receiving attention abroad. Work is also underway as a separate I.E.S. Research Project[2] on pavement reflectances. These data should be very helpful in calculating pavement brightnesses.

Night-Visibility: What Do We Want To Measure

Assume for the moment that we have several different lighting installations or that we have a design technique that would permit us to layout any kind of a brightness distribution that we might wish. What design is best for the situation at hand? There are always questions of cost to consider in highway lighting since the areas to be lighted are very large and the funds are always limited to practical amounts commensurate with the project under consideration. We are therefore faced with using a low range of average illumination (from 0.10 to 5.0 ft-c) to best advantage. The current practice is to select an average horizontal illumination within the above range for the kind of

A paper presented at the National Technical Conference of the Illuminating Engineering Society, September 14-17, 1953, New York, N. Y. AUTHORS: Division of Highways, State of California, San Francisco, Calif., and Institute of Transportation and Traffic Engineering, University of California, Berkeley, Calif., respectively. Work done under I.E.S. Research Fund Project No. 37.

service involved and then to arrange the lighting equipment accordingly. There are general suggestions in the recommended practice regarding spacing, mounting height, size of light source and type of distribution, but these quantities are still variable and can be assembled in many ways. The resulting lighting job can vary between these two extremes: (1) a roadway that is uniformly bright over its entire surface or (2) a roadway that consists of patches of high and low brightness along its length. The average illumination can be the same for each and both can be designed in accordance with recommended practice.

Serious doubt exists in many well qualified minds about the most suitable design of a highway lighting system. The questions seem to be directly related to the economics of the situation for it is generally assumed that uniform brightness necessarily means very close spacing of luminaires using small sources, whereas the same *average* illumination can be obtained using larger sources on longer spacing. The economic studies generally show that for the same *average* horizontal illumination the longer spacing is more economical. This may not be a proper appraisal, but it is frequently used. Cost plays such a large part in the selection that the visibility, safety and comfort aspects are generally of second order importance. It will never be possible to divorce the cost factors from the design of highway lighting, but it is entirely possible to design either a good visibility system or a poor visibility system for the same cost.

Our problem is to measure the visibility of objects on the roadway with a technique that eliminates subjective appraisal as much as possible. Inherently, visibility is subjective and as such it defies measurement directly. Therefore, we can only use indices that can be correlated to visibility in order to objectively quantify the term.

The most satisfactory method of defining the visibility of an object is to relate it to the threshold conditions — the conditions at which it is just perceivable. This may be done by one of several methods and to any degree of accuracy desired. The threshold may be (1) the minimum size of detail that can be seen, (2) the time to perceive, (3) the minimum brightness difference detectable or (4) the minimum contrast that can be seen at a given adaptation level. The roadway seeing situation is one in which relatively large objects (6 minutes of arc or larger) have to be recognized with certainty in a short period of time (0.2 to 0.02 seconds) at relatively low adaptation levels (1.0 to 0.005 ft-L).

For our studies the contrast threshold has been selected as the most representative phenomena to measure for the highway situation at night and is the basis for the technique herein reported.

Various instruments have been proposed and used in the past for highway visibility studies. The most important of these are listed below:

1. Luckiesh-Moss Visibility Meter[3]

This instrument has been widely used, discussed and analyzed. It consists of two circular variable density wedges located one in front of each eye and arranged to be rotated to reduce the object to a threshold value. The threshold combines obth brightness and contrast effects and the eye adaptation is not held constant. The effect of glare on the meter reading is very questionable since the optical wedges have both scattering and absorbing properties. These features limit the application of the instrument and inject serious questions regarding its use for night studies on highways.

2. Duckler Visibility Meter[4]

This meter is similar to the Luckiesh-Moss instrument except that a series of variable density glass discs are used. Threshold is determined when the object observed can no longer be seen through a glass of stated absorptive power. The instrument does not take into account the degree of contrast between the object and the background against which it is seen, and eliminates the effect of glare.

3. Philips (Bouma) Visibility Meter[5]

This is the first instrument to be designed specifically for street and highway lighting use. It is designed to measure the brightness difference threshold and consists of an optical arrangement whereby a series of variable density spots are rotated in the field until a density is reached wherein no brightness difference can be detected within the spot. The contrast does not change since both the object brightness and background brightness are reduced by the same factor. Adaptation is essentially constant and the glare effect is included. The authors have not personally used the instrument, but its utility seems to be limited because of the principle of design and its step-wise adjustment.

4. Annular Ring Visibility Meter[6]

The annular ring meter consists of a series of paper rings having external and internal diameters of 0.8 and 0.2 inch respectively, placed side by side on a glass plate which can be mounted on the windshield of a car. The rings are lit by an adjustable incandescent source. By observation the rings are noted that appear to match the lighted road surface.

5. *Street Lighting Evaluator*[7]

This device consists of three parts: A miniature pavement bed mounted over the hood of the car; a glare integrator mounted above the windshield, and a control box in the operator's compartment.

The pavement bed is fitted with a strip of simulated pavement, which by inspection, is matched to the street surface being viewed. Miniature obstacles representing pedestrians are positioned on the pavement. Brightness and Luckiesh-Moss Visibility readings are made on the pavement strip and obstacle. The glare integrator is presumed to give a measure of veiling glare. The brightness and glare readings are then used in an empirical determination to obtain relative visibility.

In practice this equipment has been found to have several limitations and has not gained general acceptance.

6. *Horton Lighting Evaluator*[8]

In this instrument the scene is viewed through a one-power monocular with a large field of view. In the focal plane of the eyepiece is a transparent disc upon which is a series of small variable density circular spots. A reading is determined by the selection of a spot which reduces the object as seen through the instrument, to threshold. It appears that this instrument is a variation of the Duckler and Philips meters.

7. *Cottrell Visibility Meter*[9]

This instrument is based upon the principle of the reduction to the contrast threshold. A constant brightness is added to a spot in the visual field while the total field is varied by an optical wedge. The device appears to work very nicely within the range for which it was designed (normal interior brightnesses) but it probably will not be satisfactory for street lighting because of the change in the brightness of the entire field and the fact that the test area of the instrument is always brighter than the surround.

After a careful analysis of the foregoing instruments and literature relating thereto, it was concluded that an ideal instrument for night visibility should include the following features:

1. The eye adaptation should remain constant at the actual roadway level while using the instrument.
2. Only a small central area approximately 3 to 5 degrees in total visual angle should be changed in making a visibility measurement. The remaining area should be unaffected insofar as brightness pattern and glare sources are concerned.
3. The change in the measurement area should cause a change in contrast without changing the average brightness and without scattering the light rays from the object and its background.
4. The total visual field should be approximately symmetrical and include about 60-degree total visual angle. A field somewhat larger is desirable if it can be achieved without compromising the optical system.
5. A reference value for the average background brightness and object brightness should be available either with the instrument or by a separate measurement.
6. If necessary a color correction filter should be provided to make the variable contrast reference source match the actual scene in color.

None of the existing instruments completely satisfy all of the above requirements, so various proposals were reviewed for a device that would accomplish the objectives. The conditions for establishing a contrast threshold were analyzed. An optical system was then developed that appeared to satisfy all of the requirements. This was subsequently built into an instrument as described in the following paragraphs.

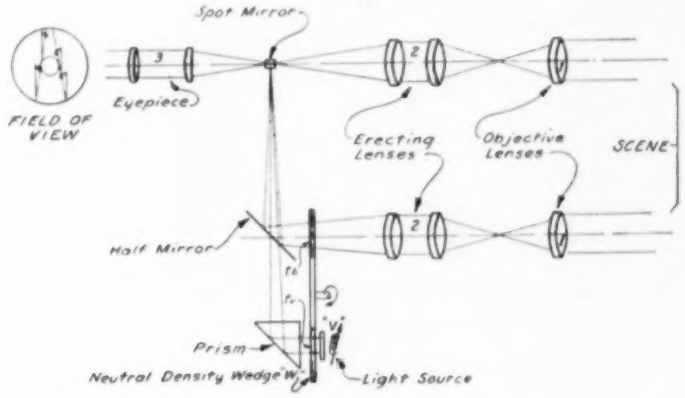


Figure 1. Instrument design.

Instrument for a Contrast Threshold Measurement

The instrument design incorporating the foregoing features is shown diagrammatically in Fig. 1 and in the photographs of Fig. 2. It consists of a monocular system with objective lenses (1) and image erecting lenses (2) so arranged that the field of view as seen through the eyepiece (3) shows in an outer annular ring the normal view of the scene through the upper monocular, while the central portion of the field of view, as seen through the lower monocular has projected upon it a variable veiling brightness source "V." The double neutral wedge "W" reduces the central portion of the scene to contrast threshold by the dual action of the reduced brightness of the scene and the added brightness of the veiling source. The principal visual field is unaffected, the average brightness of the central field remains constant, and the contrast is reduced to threshold as shown in the analysis which follows:

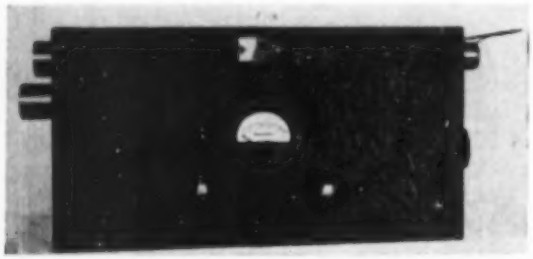


Figure 2a. Side view, showing veiling brightness controls.

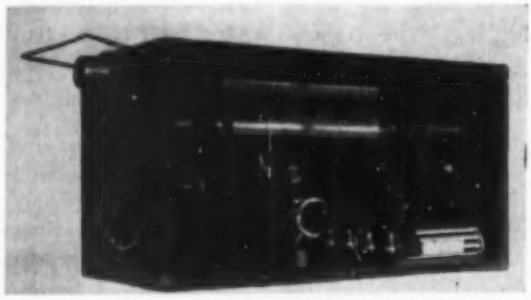


Figure 2b. Inside view, showing double optical wedge.

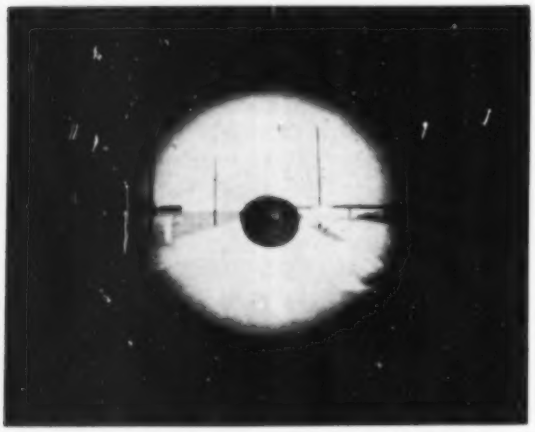
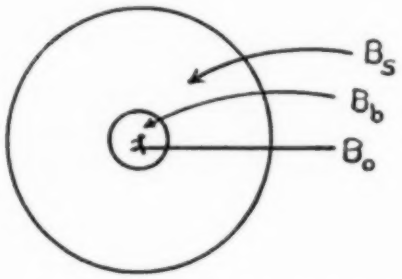


Figure 2c. Field view. Daytime view for illustration purposes; central spot is normally the same brightness as the surround.

The design is based upon the principle that a measure of visibility will be obtained when a small portion of the scene, as viewed through the instrument, is reduced to the contrast threshold.

The conditions that should occur in such an instrument are as follows:



B_b = Brightness of immediate background of object
B_o = Brightness of object
B_s = Brightness of the surround
t_b = Transmission factor of background and object filter
t_v = Transmission factor of veiling brightness filter
V = Veiling brightness
$t_v + t_b$ = constant (approx. 1.0)
K = contrast differential at threshold

Background brightness (as seen through the instrument) $= B_b - (1 - t_b)\, B_b + t_v V$

Object brightness (as seen through the instrument) $= B_o - (1 - t_b)\, B_o + t_v V$

Threshold will occur when:

$$\frac{\text{Background brightness} - \text{Object brightness}}{\text{Background brightness}} = K$$

So:

$$\frac{(B_b - (1 - t_b)\, B_b + t_v V) - (B_o - (1 - t_b)\, B_o + t_v V)}{B_b - (1 - t_b)\, B_b + t_v V} = K$$

and:

$$\frac{t_b B_b - t_b B_o}{t_b B_b + t_v V} = K$$

If $V = B_b$

then:

$$\frac{t_b (B_b - B_o)}{(t_b + t_v) B_b} = K$$

Since:

$$t_b + t_v = \text{constant} \quad \text{and} \quad \frac{B_b - B_o}{B_b} = \text{actual contrast}$$

then:

$t_b \times$ actual contrast = a constant $\times$ the contrast threshold for the particular scene, so: t_b is a measure of the visibility for the test condition.

The above relationships show that for a high initial contrast a large amount of veiling brightness is required to reduce the scene to the contrast threshold, but for a low initial contrast a small amount of veiling brightness is required. Thus the optical wedge setting can be used as a measure of the contrast threshold.

The following steps are used in the operation of the instrument.

1. Adjust neutral wedge "W" for full visibility of scene, then focus on scene.
2. Adjust neutral wedge "W" for full visibility of veiling source "V."
3. Adjust veiling source "V" to match the average brightness of the surround around the central spot.
4. Rotate neutral wedge "W" until threshold is reached in the central area, then read the dial setting on the wedge.

Preliminary Data Using the Instrument

The design shown in Figs. 1 and 2 requires the use of a double optical wedge with special characteristics such that any setting $t_b + t_v$ = constant (as near to 1.0 as possible). The maximum density is a matter of selection depending upon the type of scene to be viewed. Our preliminary estimates of the range of densities indicated 0 to 3.0 (transmittance of 1.0 to 0.001) would be about correct. Such a filter was ordered and obtained after several trials and months of delay because of its special construction. The calibration of the actual filter is shown in Fig. 3. We now find that the maximum density is too great and should be limited to 2.0 and that the transmittance should be linear with angular displacement rather than logarithmic. These modifications are in process. It is noted that the theoretical design conditions are not satisfied by the actual double wedge that was obtained, but the one on hand has been used to determine the validity of the principle of the instrument.

Both laboratory and field tests have been made to determine whether or not significant differences in meter readings could be obtained for different types of lighting systems. The laboratory data are shown in Fig. 4. In this study a small area was set up to have a reasonably uniform brightness pattern as shown in Study 1. A round object 5 inches in diameter having a matte brown colored surface was placed vertically on the simulated roadway at several distances as shown. The meter readings for contrast threshold were then made. The lighting on the area was then changed to give a spotty brightness pattern, but with about the same average value as the approximately uniform brightness pattern. Readings of maximum and minimum visibility were then made. In each case a glare source

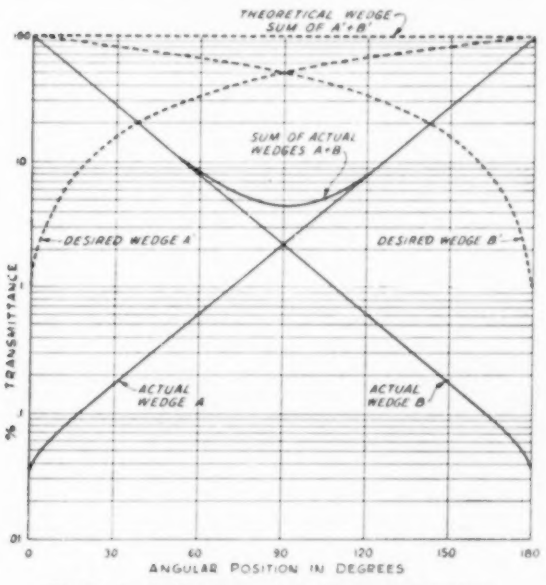
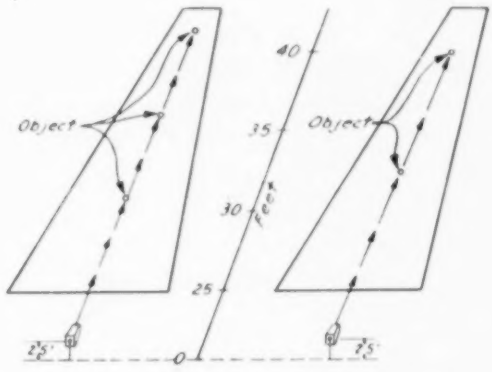


Figure 3. Calibration of double optical wedge.



Dist	Study No. 1						Study No. 2					
	Brightness (ft-L)		Meter Reading		Adjusted Meter Reading		Brightness (ft-L)		Meter Reading		Adjusted Meter Reading	
	Background	Object	No Glare	Glare	No Glare	Glare	Background	Object	No Glare	Glare	No Glare	Glare
250	1.08						2.29					
275	1.03						1.34					
300	1.36		449		270		20					
325	1.54						15	33	258	165	51	32
350	1.34	1.08	395	318	180	100	15					
375	83						80					
400	42		335		140		1.41	16	430		240	
425	43						59					
Range	37 to 1				13 to 1		15.3 to 1				47.1	
Ave	1.00						0.87					

Figure 4. Laboratory visibility study with uniform and non-uniform pavement brightness.

TABLE I.—Field Data Using Finch-Simmons Visibility Meter.

Location	Luminaire	Lamp Lumen	Lamp Type	Spacing	Mount	Road Width	Measured Illumination Max.	Measured Illumination Min.	h.f.c. Ratio	Pave. Surf.	Avg. Initial Lumen Sq. Ft. Rd.	Actual Meter Reading Glare	Actual Meter Reading No Glare	Meter Reading Adjusted to Linear Scale Glare	Meter Reading Adjusted to Linear Scale No Glare	Visibility Index* Glare	Visibility Index* No Glare
East Shore No. of Ashby	M-2	10M	Na	(2) 150'	Center	(2) 36'	0.8	0.1	8/1	A.C.	0.77	35	45	12.2	27.0	15.8	35.2
MacArthur E. of Telegraph	81-D	6M	Inc.	(2) 150'	Center	(2) 44'	0.8	0.2	4/1	A.C.	0.46	30	40	9.1	18.2	19.8	39.6
Broadway No. of MacArthur	81-D	6M	Inc.	(2) 135'	Center	(2) 41'	1.2	0.4	3/1	A.C.	0.54	50	60	43.5	91.0	80.7	169.0
26th W. of Harrison	109	16M	Hg	(2) 125'	Center	(2) 42.5'	3.0	0.5	6/1	A.C.	1.51	40	50	18.2	43.5	12.1	28.8
East Shore No. of 23rd	101-A	10M 21M	Inc. Hg	(1) 62.5'	Side	(2) 46'	1.06	0.4	2.6/1	P.C.C.	0.87	40	45	18.2	27.0	20.9	31.1
Yolo Cause.	OV20 Shielded			(1) 175'	Side	(1) 48'	2.5	0.15	17/1	A.C.	1.25	30	40	09.1	18.2	7.3	14.6

*NOTE: In order to have a common basis for comparison, the meter readings have been adjusted to an initial avg. illumination of one lumen per sq. ft. of roadway surface.

was introduced to see whether or not its effect was included in the meter reading.

The field data that have been taken to date are shown in Table I. Six different roadways were investigated. Each had a distinctively different lighting system and light source including incandescent, mercury vapor and sodium vapor types. These data are preliminary and were taken primarily to determine whether or not the instrument would yield significantly different readings for present types of lighting systems. No significance should be given to the actual meter readings as reported, but some conclusions can be drawn from the relative values.

Summary and Conclusions

An optical system for a contrast threshold visibility meter has been assembled in an instrument that is suitable for the range of brightnesses encountered on streets and highways at night. The present design is not entirely satisfactory in that the field of view is not quite as large as desirable, there is some paralax in the eyepiece and the transmission gradient of the optical wedge is not linear. These minor difficulties are being worked upon and should be corrected in the near future.

The laboratory tests revealed some interesting results concerning approximately uniform versus non-uniform pavement brightnesses. The brightness ratio for the most uniform condition was 3.7 to 1. In this case the adjusted meter reading for an object located at various points varied from 14 to 27. Because of the non-linear characteristics of the optical wedge, this change should not be expressed as a percentage.

For the non-uniform sample pavement the brightness ratio was 15.3 to 1 and the adjusted visibility meter reading varied from 5 to 24. In this case a reading of 5 indicates a very much lower visibility than the lowest value for the uniform brightness sample. The highest reading is about the same as the best on the uniform pavement. The significant feature is that the uniform pavement tends to have uniformly good visibility; whereas the non-uniform pavement has wide fluctuations in visibility from poor up to but no better than the uniform pavement.

The glare source used in the laboratory experiments caused a significant reduction in visibility meter reading. A great deal more work has to be done on this before the meter readings can be properly interpreted. It is interesting to note the magnitude of the change in meter reading with glare. The changes in visibility are very great especially for the non-uniform brightness pattern. This may turn out to be a principal factor in establishing the importance of pavement brightness patterns.

The field studies were made under actual traffic conditions using moving vehicles as objects. This was an interesting experiment and seems to have considerable merit for future work in which the effects of motion, time and specular reflections will be considered. The meter readings show significant differences among systems and between the readings on the same system with and without shielding from the street lighting sources. The readings shown as "no glare" were taken by placing a shield over the front of the instrument to block out the field of view containing the highway lighting units. One method of comparing the systems is shown under the heading of "visibility index" in which the meter reading per horizontal footcandle was computed to give the index. While the horizontal illumination is not directly related to pavement brightness, it has been observed that a small ratio

of horizontal illumination generally produces a more uniform pavement brightness pattern than a large ratio of h.f.e. The meter readings and visibility ratings shown in Table I are by no means conclusive, but they do tend to indicate that the basic concepts in the American Standard Practice for Street and Highway Lighting are substantiated in that the pavement should have good uniformity of brightness with reasonable freedom from glare.

Additional work is in progress on the technique and instrument described above and will be presented in a report at a later date.

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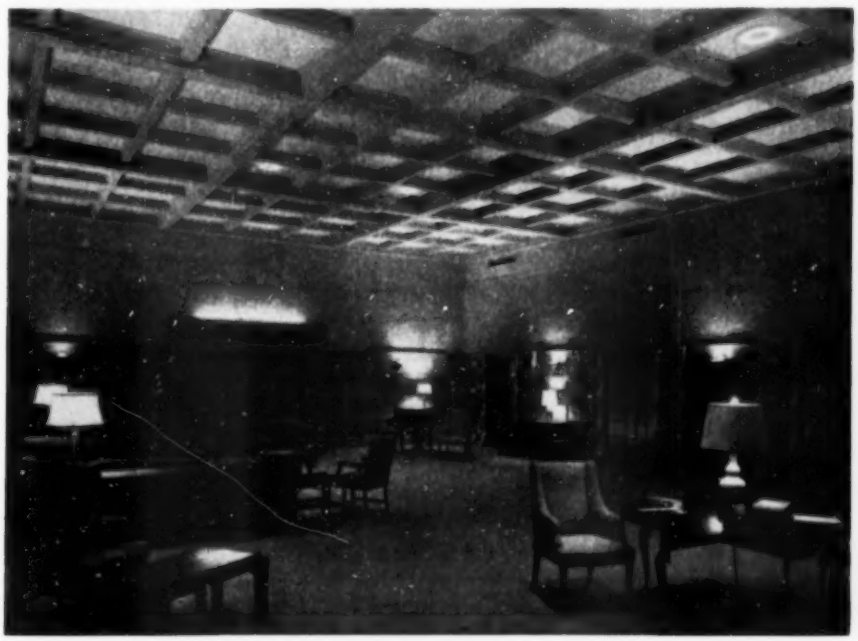
Variable Lighting System for Multi-Purpose Room

This lounge area, 40 x 60 feet, of the Pasadena Presbyterian Church is used for wedding receptions, teas, lectures, committee meetings, television, reading, general relaxation for groups or individuals and for any social or spiritual needs the church and its members may wish. Due to the multiple purpose of the room, it is likely that the furniture is often moved around or removed entirely.

Neither the donor nor the architect was interested in a completely recessed lighting system, yet they wanted diffused lighting with highs and lows. Wall urns with R40 300-watt floodlamps supplied this diffused lighting. To provide highlights, three 100-watt flush asymmetric units are recessed over the drapes in the alcove and a 75-watt recessed spot is used over the fireplace (effectively lighting a wedding couple at a reception). Four 200-watt downlights in gold reflectors are used in the center of the room, and two 300-watt R40 lamps in swivel units spotlight a lecturer or musical group. One 8 foot fluorescent strip was built into the heading above the doors to provide backwall illumination during the showing of slides.

Since the beams presented a shadow problem, shadows around the perimeter of the room were avoided, and a few major shadows run the length of the room to create interest in the ceiling.

This installation, by Del Reynolds, Lighting Consultant, Southern California Edison Co., was runner-up in the Southern California Section's contest for My Most Interesting Lighting Job.



Design Characteristics of a Photo-Electric Brightness Meter

By KARL FREUND

Describing the development and characteristics of a meter to measure wide ranges of brightness automatically and accurately.

A GREAT NEED has frequently been indicated by various groups such as illuminating engineers, television tube manufacturers, airplane instrument manufacturers, police departments and others, for an instrument that would measure the brightness of small areas from a distance and still be sensitive enough to read down to a few footlamberts or less. In view of this need, it was decided to explore the possibility of developing such an instrument.

The first solution in this project was a rather elaborate optical system with a photomultiplier tube and associated electronic system requiring a-c line current to operate and weighing about twenty-five pounds (Fig. 1). It covered a viewing angle of 1 degree and measured brightness from 1 footlambert to 1000 footlamberts. This was a step in the right direction but for most applications a light, portable, self-contained instrument was desired. Dr. William Baum of Mount Wilson-Palomar Observatories had done considerable work on small battery operated circuits for the measurement of star brightness. By making the optical system more compact and by adapting the extremely sensitive stellar photometer type circuit, an instrument was developed which measured a wide range of brightness, required no external power source and weighed less than five pounds. The Spectra Brightness Spot Meter, as it is called (Fig. 2), is a direct reading instrument with the extremely small acceptance angle of only one and one-half degrees. It will measure brightnesses from one-tenth (0.1) of a footlambert up to one million (1,000,000) footlamberts. The optical system of the meter consists of a four-element f 1.9 lens in focusing mount which forms an image of the region to be measured on a reticule in the optical housing. A circle in the center of this plate indicates the exact extent of the area being measured. This image is viewed magnified through a telescopic eyepiece. A partial reflecting mirror just ahead of the reticule plate reflects a portion of the light downward to the photo tube. An opaque aperture plate is located at the focus of this light beam directly above the photo tube. This plate excludes all light except the portion of the image that corresponds to that within the circle of the reticule. The light emerging from this aperture passes through a filter wheel and then onto the cathode of the photo tube. The output from the photo tube passes through the resistor selected by the range switch. (See Fig. 3.) The voltage produced in this resistor is duplicated with a current amplification of as much as one million times by a special electrometer tube amplifier. This output current is then read on a logarithmic response microammeter which is calibrated to read directly the footlambert brightness of the surface viewed (Fig. 3). The scale is calibrated from 1 to 100 footlamberts. Range multipliers of 0.1, 1, 10, 100, 1000, and 10,000 are available on the range switch. A locking type microammeter is used so readings may be held fixed as long as desired. This is particularly useful when the meter is hand-held. The reading is captured by merely pushing and releasing the button on the side of the meter case. The reading is then retained until the button is again depressed. When scanning with the instrument on a tripod the meter can be

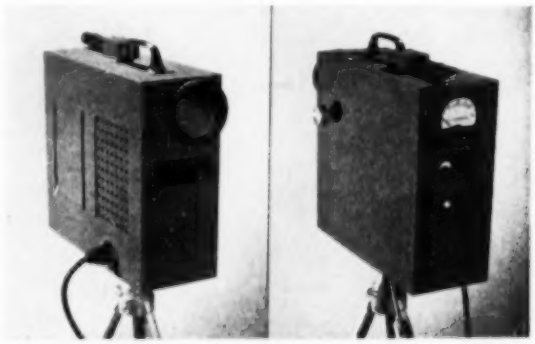
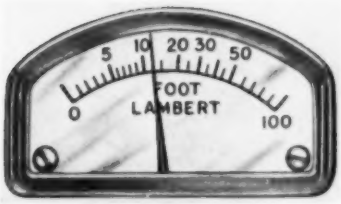


Figure 1. Early models in the development of the new meter employed an elaborate optical system, and weighed about 25 pounds. Brightness measurement range was from one to 1000 footlamberts.

A paper presented at the National Technical Conference of the Illuminating Engineering Society, September 14-17, 1953, New York, N. Y. AUTHOR: Photo Research Corporation, Burbank, Calif.



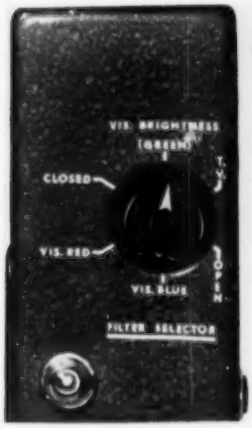


Figure 2. (left) The present meter with hand grip. Weight is now about five pounds, and measurement range is from 0.1 to one million footlamberts. Figure 3. (center) Logarithmic meter scale. Figure 4. (right) Filter selector.

made to read continuously by merely depressing and then turning the button. The logarithmic scale makes the percentage accuracy approximately uniform over the entire length of the scale. Accuracy is better than five per cent of reading over the entire range of sensitivity and is maintained throughout the life of the batteries.

A six-position filter wheel is incorporated in the instrument and is controlled by a knob located on top of the case (Fig. 4). The accuracy to which the sensitivity of the instrument matches the ICI luminosity curve when on the "Visual Brightness" position is indicated in Fig. 5. The "Closed" position of the filter wheel completely excludes light from the photo tube and is used when zeroing the instrument. A red filter and a blue filter fill two of the remaining positions in the wheel. A filter approximating the sensitivity of the image orthocon and an open position that can be used with any external filter completes the filter wheel. The relative amounts of red and blue light in different areas can be read with the corresponding filters in position. With the addition of an adjustable iris, which mounts directly in the threaded ring in the front of the lens barrel, the Spectra Brightness Spot Meter can be furnished calibrated as a direct reading color temperature meter. With the red filter in position the iris is adjusted until the needle of the microammeter comes to a red reference mark on the scale. The filter wheel is rotated to blue, and color temperature or color index is read directly on the blue-red index scale. By rotating the filter wheel to green the green-red color index can be read on its corresponding scale.

Where interest is primarily in how color films will respond to the light rather than its visual color, a special model of the meter can be used with filters matched to the average response of the red, green and blue sensitive portions of color film. The reading of a light source whose spectral distribution closely approximates a black body will be the same on both models of the instrument but, when light sources that differ widely from black bodies are read, the two models will indicate different color indexes showing that these sources do not appear the same to the color film as they do to the eye.

A jack is mounted on the right side of the instru-

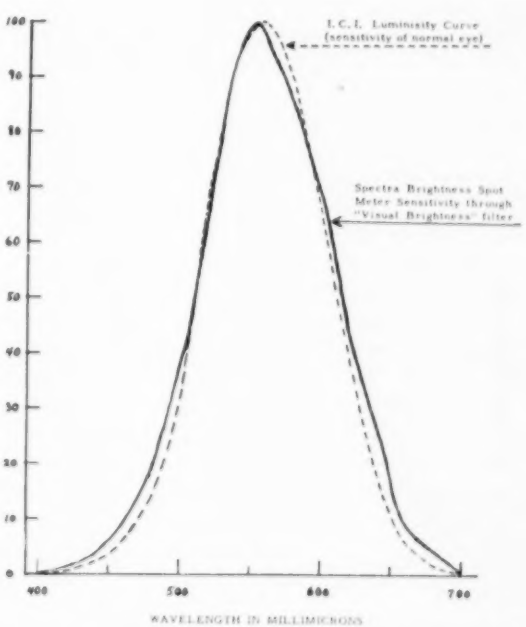


Figure 5. Showing the accuracy to which the sensitivity of the instrument matches the I.C.I. luminosity curve when on the "visual brightness" position.

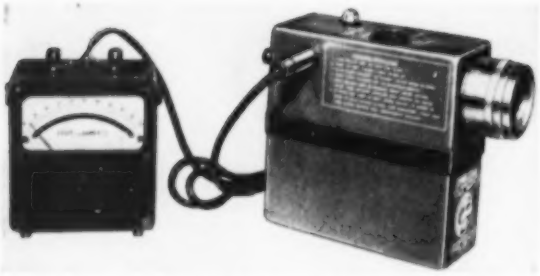


Figure 6. External meter or recorder may be attached to the meter.

ment where an external meter or recorder can be plugged in (Fig. 6). A larger microammeter is available which can be plugged to this jack where greater accuracy is desired or for more rapid reading when two operators are available. One operator scans the scene while the second reads and records the results. Where a permanent continuous reading is desired, a recorder can be operated from this same outlet.

The lens barrel is engraved with a distance scale from five feet to infinity. The lens can be focused on objects still closer but error is introduced due to the increased focal distance. Where highest accuracy is desired, supplementary lenses should be used with reading areas closer than six feet. Five supplementary lenses are regularly available and others can be made to order. The first covers an area of one and one-half inches at five feet, a second covers one inch at forty inches, a third one-half-inch at twenty inches, a fourth one-quarter inch at ten inches, and the fifth is a four-element supplementary lens covering an area of one-tenth of one inch in a diameter at a little over two inches in front of the supplementary lens. Brightness of a very small area such as luminous marking on dials can be thus measured.

The battery component which fits compactly in the base of the instrument is readily accessible and consists of six Mallory RM-12 1¼-V. cells, two Everready No. 411 15-V. cells, one No. 412 22½-V. cell, and four No. 413 30-V. cells. When the meter is to be used continuously for long periods of time at a single location, an external power supply operating from 60-cycle line current may be used to replace the batteries. An application of special interest, particularly with the present trend to wide screens, 3-D screens and the like, is its use in screen brightness measurements. Being small, light and requiring no external power it can be taken anywhere in the auditorium so that the screen brightness can be measured from any viewing angle. The small angle of view means that not only can the average brightness be read from each angle but the evenness of the light reflected in that direction over the screen area can be measured. If a patch of known reflectance and color of sufficient size to fill the angle of view of the meter is placed against the screen the footcandle level of illumination produced by the projector at the screen can be read. By comparing the readings of this standard patch with that of the screen measured through each of the primary color filters, the reflectance of the screen and amount of color modification produced by the screen can be measured.

A great many uses for the meter have already been suggested by the illuminating engineers, photographers and others who have used it. Doubtless many more will be added when the meter comes into more general use, as it is the first commercial instrument for measuring the brightness of small areas that eliminates the errors inherent in visual methods.

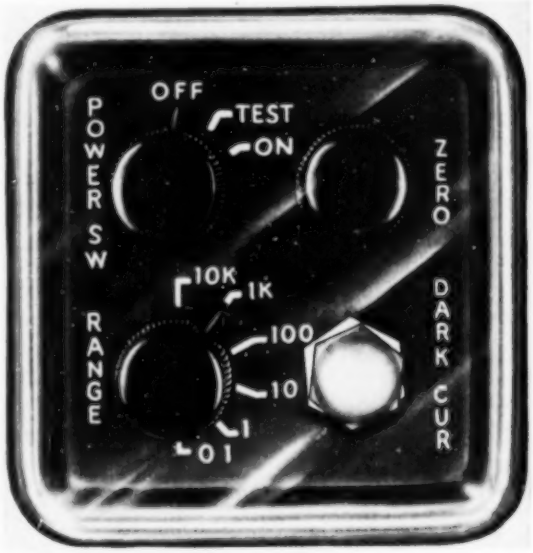


Figure 7. Range switch.

INSTALLATION AT ANDERSON, CLAYTON AND COMPANY, 494 SPRING ST., ATLANTA, GEORGIA.

Lighting a Cotton Classing Room

LIGHTING OBJECTIVE: To provide electric illumination of suitable quality for grading raw cotton.

GENERAL INFORMATION: Raw cotton is classed according to the length and texture of fibers and color. Cotton samples come in a variety of off-shades of white, small variations in which must be discernable to the grader. Professional graders long used to working under north skylight have been reluctant to accept electric lighting, although they have complained about variations in daylight. In the past, classing was done under large skylights of relatively uniform brightness, only during those hours when no direct sun was incident on the windows and only on days with favorable weather conditions.

The area shown above measures 80 x 70 x 9 feet. Surfaces are finished as follows:

walls	gray	58% RF
ceiling	white	81% RF
floor	natural wood	41% RF
work surfaces		
table top	gray	37% RF
inspection of fiber length	marbelized black linoleum	10% RF

The original black tables were painted gray to cut down brightness contrasts. However, after this change it was more difficult to judge accurately the length of the cotton fibers. Therefore, small black marbelized linoleum pads were added to the tables to give a background over which the cotton samples are held for this part of the grading process.

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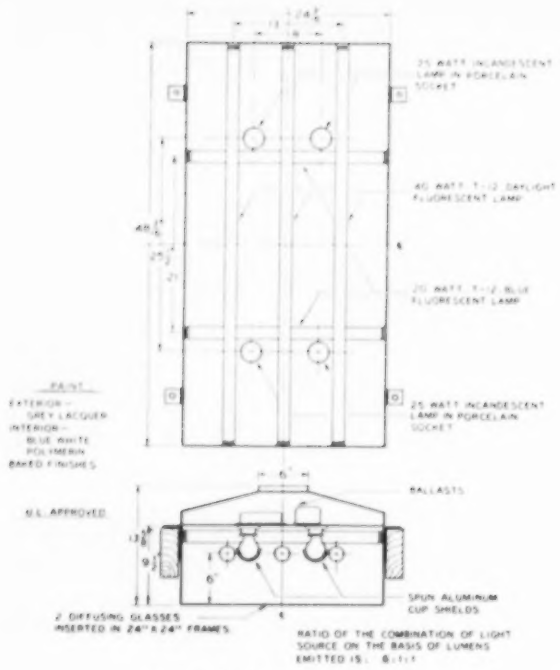
25 WATT INCANDESCENT LAMP IN PORCELAIN SOCKET
40 WATT T-12 DAYLIGHT FLUORESCENT LAMP
20 WATT T-12 BLUE FLUORESCENT LAMP
25 WATT INCANDESCENT LAMP IN PORCELAIN SOCKET
PAINT
EXTERIOR — GREY LACQUER
INTERIOR — BLUE WHITE POLYMERIN BAKED FINISHES
U.L. APPROVED
BALLASTS
SPUN ALUMINUM CUP SHIELDS
2 DIFFUSING GLASSES INSERTED IN 24" X 24" FRAMES
RATIO OF THE COMBINATION OF LIGHT SOURCE ON THE BASIS OF LUMENS EMITTED IS: 8.1:1

Figure 2. Luminaire detail.

Lighting a Cotton Classing Room (continued)

INSTALLATION: Continuous rows of Macbeth Examolite Type C glass-covered troffers (120 units in all) are spaced 8 feet apart. As shown in Fig. 2, each unit contains three 40-watt daylight fluorescent lamps, two 20-watt blue fluorescent lamps, and four 25-watt inside-frosted incandescent filament lamps.

Fig. 3 shows the resultant illumination. Brightnesses are as follows:

luminaire (approx. 45° in azimuth and elevation)	378	ft-L
ceiling between luminaires	15	ft-L
column	25	ft-L
cotton	49	ft-L
work surface		
gray	12	ft-L
black	7	ft-L
floor	28.5	ft-L

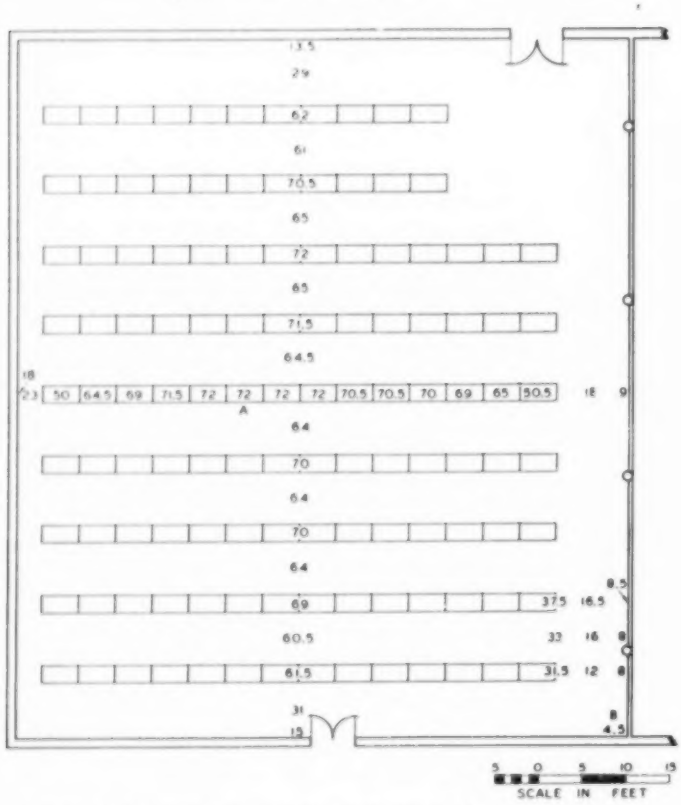

Figure 3. Footcandles on horizontal plane 33 inches above floor after 700 burning hours.

Lighting data submitted by Macbeth Corporation, Newburgh, New York and Jack H. Murrah, Georgia Power Company, Atlanta, Georgia, as an illustration of good lighting practice and to aid in the design of similar installations.

Published by the Committee on Publications of the Illuminating Engineering Society, 1860 Broadway, New York 23, N. Y.

Some Observations of Fluorescent Street Lighting Here and Abroad

By PHILIP H. HOUSER

IN 1945 the I.E.S. Street and Highway Lighting Committee sponsored fluorescent street lighting tests in Detroit, Cleveland, and Schenectady.[1] The Committee arrived at a number of interesting conclusions and made two recommendations:

1. That manufacturers give further study to fluorescent lamp luminaires which are suitable structurally for street-lighting service and which direct as much light at favorable angles up and down the street as may be practicable.
2. That municipalities, utilities, and the I.E.S. cooperate in further test installations in the event that more effective luminaires or sources are achieved.

Evidence to date indicates that our friends across the ocean were more expeditious in developing the potential of fluorescent roadway lighting than we were. In August 1946 the British lighted High Street in Rugby and Bond Street in London. By the end of 1950, over sixty British towns had installations of twelve units or more — the largest at Rugby numbering 247 units.[2] At the present time the number of installations is well over 100 and the number of fixtures per installation greatly increased; for example, Rugby's has risen from 247 to over 400 fixtures, covering approximately twelve miles of streets.

This expansion is said to be only a fraction of what it would have been if fluorescent lighting had not been severely handicapped by Britain's restrictions on capital investment and power which have resulted instead in a wide usage of sodium street lighting.

These restrictions are quite severe and even if a town has the money to spend, it cannot do so without approval of the Ministry of Commerce and the Ministry of Transport. At present these approvals are difficult to obtain; however, it has been demonstrated that an interested populace can exert sufficient pressure to obtain approval for downtown fluorescent installations where improved color rendition is important.

The French were stimulated by the successful English experience and in 1947 the City of Paris

Figure 1. One of the first English installations, High and Sheep Streets, Rugby. Each luminaire is equipped with three 5-foot 80-watt lamps; mounting height 25 feet; spacing High Street (left) 100-foot center suspended; Sheep Street (right) 120-foot staggered. Street width varies from 15 to 25 feet. Approximate illumination level is 1.2 footcandles. (British Thompson-Houston Co. Photo.)

Figure 2. A more recent English installation, Cowley Road, Oxford. Each luminaire is equipped with three 5-foot 80-watt lamps; mounting height 25 feet; spacing 80 to 100 feet staggered; street width 30 feet. Approximate illumination level is 1.2 footcandles. (British Thompson-Houston Co. Photo.)

A paper presented at the National Technical Conference of the Illuminating Engineering Society, September 14-17, 1953, New York, N. Y. AUTHOR: Lighting and Rectifier Dept., General Electric Co., West Lynn, Mass.

Figure 3. An outstanding French installation at the corner of rue des Pyrenees and Cours de Vincennes, Paris. Each luminaire is equipped with four 100-watt 5-foot lamps. Cours de Vincennes mounting height is 30 feet, spacing 82 feet opposite, width of road 92 feet, luminaire overhang approximately 6 feet and tilted upward at angle of 45 degrees. Approximate illumination is 1.6 footcandles.

decided to make their initial installation on part of the Avenue du President Wilson.

They have become quite enthusiastic about fluorescent lighting and feel that it is comfortable, soft, and comparatively glareless. Paris itself now has about 6000 fluorescent lamps in street lighting service; and fluorescent lighting is rapidly spreading to the provinces.

The French enthusiasm is further indicated by the fact that half of Paris' $750,000 annual budget for new street lighting installations is being devoted to fluorescent lighting.

Similar activity may be observed in Italy, where Milan, Rome, and other cities now have fluorescent installations.

Returning to the United States, Detroit's 1945 test installation led to the first municipally-financed fluorescent installation meeting the requirements of the American Standard Practice of Street Lighting. This installation was put in service in Detroit late in 1950 (Fig. 5). The resulting illumination, averaging approximately one footcandle, has been acclaimed for its high visibility and "seeing comfort."[4, 5]

Additional major installations were made in Lydonville, Vermont (Fig. 6); Portland, Oregon; and Schenectady; as well as a number of small trial installations throughout the country.

As a result of the success of these experiments in the application of fluorescents to roadway lighting plus the popularity of fluorescent lighting in Britain and Europe, a new unit was developed and made available in 1952. It employs a new 100-watt 96-inch T12 standard cool white rapid-start lamp[6] developed specifically for street lighting. It provides control of light along established street lighting principles, as indicated by the light distribution curve in Fig. 7. It employs what is believed to be the largest clear acrylic plastic piece yet produced by injection molding. The first installation of this new unit was made in December 1952 at Oakwood, Ohio, a suburb of Dayton.

Let us now consider what has been behind the growth of fluorescent street lighting in England. Initially it was a desire to conserve power and thus save coal and reduce the load on electrical generation and distribution facilities. Now, however, it is reported to be a desire to get more and better seeing comfort — essentially the same reasons that have been responsible for the tremendous growth of fluorescent interior lighting in the U. S.

Figure 4. Day view of Cours de Vincennes, Paris.

Figure 5. First U. S. installation, Wyoming Avenue, Detroit. Each luminaire equipped with four 96-inch T-12 lamps (approximately 20,000 lumens total); mounting height 25 feet; spacing 100-140 feet staggered; street width 46 feet. Average calculated illumination is 1.0 footcandle.

This raises a question: how much better is fluorescent street lighting? It is hard to evaluate. Fundamentally, what we are actually concerned with are seeing and comfort. Secondary criteria such as footcandles, ratio of average to minimum, and utilization have been developed and reasonably correlated with seeing and visibility. However, it is the opinion of many European experts that these criteria do not apply to long-source, low-brightness fluorescent lighting in the same way as they do to comparatively small source, high-brightness incandescent and mercury luminaires.

It appears in the case of fluorescent lighting that it will be necessary to go back to fundamentals and replace these criteria by a comprehensive factor covering "see-ability" and another covering seeing comfort.

As to "see-ability," on *wet* pavements the wide bands of reflected brightness achieved with fluorescent lighting are tremendously effective in silhouette seeing. In contrast, incandescent and mercury lighting are generally least effective on wet pavements. On *dry* pavements many experienced qualified observers are convinced from visual appraisals that substantially *better visibility* is obtained under fluorescent street lighting than *under equal footcandle levels* with modern incandescent or mercury installations. Some observers have expressed the opinion that *equal visibility* requires at least 1½ times the footcandle level with modern incandescent or mercury as with fluorescent lighting.

Since we have not yet been able successfully to put numerical values on "seeing comfort" or to appraise adequately the difference in seeing effectiveness between fluorescent and smaller higher-brightness sources, it appears that fluorescent street lighting must be seen to be properly appreciated; and apparently this visual appraisal has been responsible for its rapid spread in Europe and Great Britain.

Variations in light output with temperature and reliable low-temperature starting have been an important concern in this country, while Europe has

Figure 6. An excellent U. S. installation at Lydonville, Vermont. Each luminaire equipped with four 96-inch T-12 lamps operated at 600 ma. Mounting height is 30 feet; spacing 60-70 feet staggered.

had less of a problem due to its more moderate and even temperature.

The 1945 experimental installations used glass "jackets" over the lamps to maintain lumen output in cold weather. The 1950 model used slimline lamps, thereby obtaining reliable low-temperature starting. However, the reduction in light output at low temperatures indicated need for improvement. The latest luminaire uses a rapid-start street lighting lamp having reliable low-temperature starting and excellent stability of light output throughout the temperature range of operation as a result of its heavier current loading. A comparison of the performance of the two fixtures is given in Fig. 8. It will be noted that the light output of the new unit is actually greater at lower temperatures, thereby facilitating seeing under adverse weather conditions.

Rapid-start lamps are particularly advantageous in street lighting applications since they offer the advantages of pre-heated cathode operation and yet avoid the difficulties of starter-switch operation which have proved to be troublesome in European installations to such an extent that they, too, are going to a somewhat similar system. The use of preheated cathode type lamps in street lighting applications was felt to be desirable since this facilitates operation at higher currents with consequent greater stability of light output with temperature variation, long lamp life, and lighter weight ballasts approximately half as large as the ballast used with the previous slimline fixture.

While fluorescent installations do, of course, require ballasts or transformers, these are functionally the equivalent of the familiar mercury ballasts. Actually, due to the large size and lower operating temperature of the fluorescent luminaire, either constant-current series or multiple ballasts may be mounted inside the fixture, making the actual field installation wiring simpler than that of a mercury luminaire and comparable to that of an incandescent system.

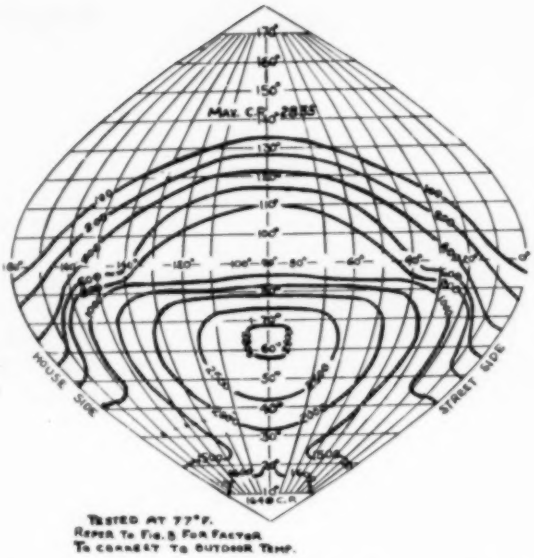

Figure 7. Distribution curve for U. S. fluorescent luminaire using four 100-watt rapid-start street lighting lamps.

The design of a successful fluorescent street lighting luminaire presents many problems not generally encountered in interior fluorescent work: the fixture must be strong and weatherproof to withstand the rigors of outdoor pole mounting; its optical system must be designed to provide a street

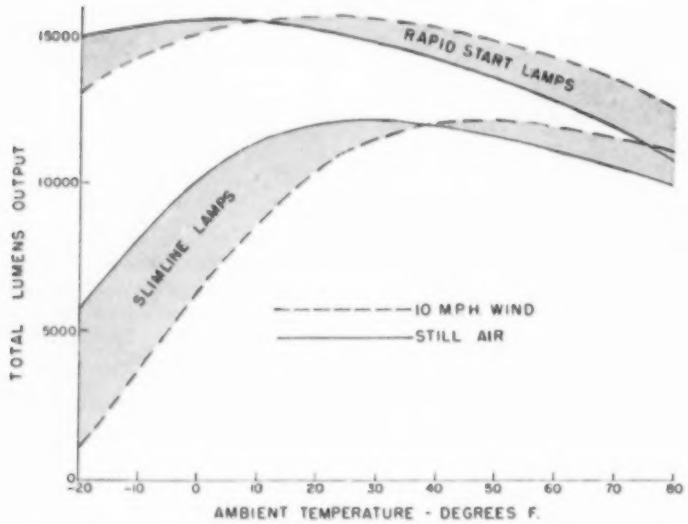

Figure 8. Variation of light output with temperature for luminaire using four 600 ma 90-watt slimline lamps, and luminaire using four 100-watt rapid-start lamps.

Figure 9. A recent U. S. installation at Far Hills Avenue, Oakwood, Ohio. Each luminaire is equipped with four 100-watt rapid-start street lighting lamps (approximately 20,000 lumens total). Mounting height is 30 feet; spacing 95 feet along center line. Average initial illumination is 1.7 footcandles.

lighting type of distribution having light flux concentrated with high candlepower at relatively high angles; a lamp having good starting characteristics and good stability of light output at low ambient temperatures must be used and the design of the luminaire and ballast system must be closely coordinated with the lamp characteristics to assure a combination that is both reliable and consistently high in performance.

One of the other major points raised in the 1945 test report was that of economics. It is obvious that the initial cost of a fluorescent installation is greater than that of an incandescent or mercury installation of equivalent footcandles. Our European friends list among the counteracting forces higher efficiency, long lamp life, low maintenance and servicing expense, more effective seeing, and public acceptance. Mr. Ludovic Gaymard, Street Lighting Engineer for the City of Paris, has estimated that in Paris the extra initial cost of a main-road fluorescent installation will be recovered within five years.[3]

In the United States, the Oakwood installation (Fig. 9) and others have been noteworthy, not only in novelty and visibility and seeing comfort, but also in the resultant community pride that they appear to have aroused. Remembering that street lighting, regardless of engineering excellence, is a commodity that must be sold to and paid for by the public, such community awareness and enthusiastic acceptance are factors of prime importance.

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And Fluorescents In An Amusement Park

In this first installation of its type, 15 fluorescent street lighting luminaires were recently installed at Paragon Park, a beachside amusement area near Boston. The 15 luminaires are mounted horizontally at a height of 19 feet, spaced lineally around the horseshoe-shaped boardwalk at a distance of 80 to 90 feet. Illumination is 4.5 to 5 footcandles immediately beneath the units and about one-half this level between luminaires. *Photo courtesy General Electric Co.*

The Development of Highway Lighting in Metropolitan Chicago and Northern Illinois

By RICHARD J. SEITZ
EDWIN M. PRIMS

AS A RESULT of numerous studies, conferences and inspection tours, extending over the past fifteen years, by the agencies involved in planning, designing, and constructing highways in Metropolitan Chicago, Cook County and Northern Illinois, lighting of expressways has become a reality. The first of these modern high speed roadways in this area to be illuminated is the completed fourteen-mile portion of Edens Expressway from approximately Foster Avenue to its termination just north of the county line. The Cook County Highway Department, designers of this portion of the Expressway, were firm in their belief that such roads should be illuminated outside the city limits and it took the opening of Edens to traffic to convince the participating agencies that fixed lighting of these roads is essential for the safe movement of night traffic. This new limited access roadway, extending north from Chicago and feeding large volumes of traffic to and from North Shore suburbs and through traffic to Milwaukee, is now being illuminated to a level slightly less than 1.0 footcandle.

Mercury vapor lighting units are being installed throughout the present fourteen-mile length and when completed within the next few months will set the pattern for additional roads now under construction as planned for the expressway grid system of "Greater Chicago."

Early Trends

In the early 1920's, the utility company recognized the need for practical information regarding lighting in the planning, designing, operating and maintenance of street lighting. By 1935 more than 200 municipalities in Northern Illinois had availed themselves of this lighting service. It then also became apparent that studies should be made and equipment developed for the lighting of arterial roads leading into and connecting these municipalities.

This realization, of course, was not confined to Northern Illinois. Throughout the country, thinking people were awakened to the need for reducing the night traffic accident rate especially on our main highways.

An Early Utility Company Experiment

One of the first substantial installations of highway lighting was planned, designed and constructed by the utility on a one-mile stretch of Skokie Highway, the forerunner of the modern Chicagoland Expressway. This early highway lighting system contained twenty-six 10,000-lumen sodium vapor units mounted on steel standards 25 feet above the pavement. The standards were located 6 feet from the pavement edge and were placed along both sides of the 40-foot roadway in a staggered arrangement about 250 feet apart (Fig. 1).

In addition to providing considerable technical data and experience, the installation received many favorable comments from the motoring public. On November 6, 1936, the Chicago Section of the Illuminating Engineering Society held its regular meeting near the demonstration mile and then made an inspection of the system. The installation was given considerable newspaper publicity and engineers and interested people from all over the nation made special efforts to inspect the system and obtain details.

An Early State of Illinois Experiment

Interest was naturally high in the State and County Highway Departments for additional safety measures which would assist them in arresting and reducing the mounting night traffic accident rate. In a comparatively short time results from a number of test lighting installations were proving effective and economically feasible.

About one year after the Skokie Highway installation was completed, the State of Illinois installed lighting on a particularly hazardous stretch of Busse Highway, a new section of U. S. Route 12 leading west from Chicago. This system contained seventeen 10,000-lumen sodium vapor units of the type and mounting as those on the Skokie system except spacing was designd to fit the "S" curve of the roadway. (Fig. 2)

Thirteen months after the first state installed

A paper presented at the National Technical Conference of the Illuminating Engineering Society, September 14-17, 1953, New York, N. Y. AUTHORS: Division Manager, Commercial Sales, and Division Street Lighting Engineer, Public Service Company Division Commonwealth Edison Co., Northbrook, Ill., respectively.

lighting was placed in service, the Illinois Highway Department issued a statement that not one single accident had occurred from the turn-on date of the system. In the few years prior to the installation there had been nineteen major accidents on this stretch of highway, all but one occurring at night.

By 1940, four years after its installation, the lighted mile of Skokie also had maintained a fine accident record compared to other sections of the highway. The Highway Department released a report at that time of the number and causes of accidents on this highway over an eight-mile stretch in Cook County. This report gave accident data for each intersection and stretch of roadway and further stated that there were no fatal accidents in the lighted portion of the highway.

Post War Planning

Following a directive of the President in 1941 and the subsequent report of the National Interregional Highway Committee, local authorities began planning a broad system of highways in the vicinity of Chicago which in turn were to form a part of the Interregional Highway system throughout the country.

During the war years the Cook County Highway Department in cooperation with the State, City of Chicago and the Public Roads Administration took a leading role in post war highway planning for the Chicago area. Along with the Chicago Subway and Superhighway Commission and the Chicago Plan Commission, the Cook County Highway Department set up planning and land procurement departments and by early 1944 were well launched on a 300-million-dollar program. These plans included routes and detailed designs of Edens Expressway, a new north outlet from the city, Congress Street Superhighway to the west, Northwest Superhighway to the northwest, Tri-State Superhighway to the south and River Road Expressway by-passing the city. All are designed to be limited access roads, depressed or elevated as the terrain dictates and each to consist of two 36-foot express pavements divided by a median strip.

First Lighting Plan for Edens

The first complete plan to be announced for immediate construction in this broad program was Edens Expresway. This highway extends from Elston Avenue in Chicago to Highland Park, a distance of fourteen miles, where it connects with Skokie Highway, the existing divided expressway to Milwaukee. In addition to the straight-a-way, the project includes twenty-three bridged intersections and eight traffic interchanges. The original plan called for the utilization of every known traffic safety feature except lighting. However, before the plans were completed the Cook County Highway Department requested the utility company and others to make a lighting study for the project.

The first proposed lighting system consisted of 10,000-lumen sodium vapor units mounted 25 feet above the pavement and placed in the median strip between the two roadways. Units were spaced about 200 feet apart on the straight-a-way with each standard supporting two luminaires on long mast arms. In accordance with the then current Illuminating Engineering Society recommendations, the system was designed to produce about 0.3 footcandles of light on the pavement. This proposal was thoroughly studied by the planning agencies but was finally filed for future reference with the thought that before the road was com-

Figure 1. Sodium vapor lighting on Skokie Highway (U. S. Route 41), Northbrook, Ill. — 1936.

Figure 2. Sodium vapor lighting on Busse Highway (U. S. Route 12), Park Ridge, Ill. — 1937.

pleted, new design and refinements in lighting practices for superhighways would be developed. Local engineers were made aware of the desire of many highway designers to avoid, if possible, tall poles and long brackets both from the standpoint of appearance and safety.

Low Mounted Lighting Equipment

Following up the desire of local highway engineers for a new study of the lighting problem for superhighways, the utility, in cooperation with the City of Chicago and Cook County engineers, installed a test section of low mounted silhouette lighting on a 40-foot roadway to compare it with an adjacent high mounted conventional installation. The roadway selected was set up to simulate one lane of a superhighway with 10-foot shoulders, no parking and no pedestrian traffic.

Since an analysis of the problem revealed it to be primarily one of silhouette seeing which requires high pavement brightness, it was thought that low mounted units (4 to 7 feet) directed against the oncoming traffic would efficiently meet the requirements by utilizing the high reflection factor of the pavement at grazing angles. Glare was to be controlled by directing the beam below eye level and by eliminating direct light from the lamp filament.

Twenty standard 300-watt searchlight type units with 10-inch focal length reflectors and 12-inch cover glasses were used in the original installation. The units were mounted 10 feet from the edge of the pavement with a 50-foot staggered spacing at an elevation of six feet and directed so as to intersect the center line of the road at a distance of 100 feet, measured parallel to the roadway. (Fig. 3) Even though the units were equipped with spherical reflectors to prevent direct rays from reaching the driver's eyes, it was found necessary to equip them with deep, closely spaced louvers. (Fig. 4)

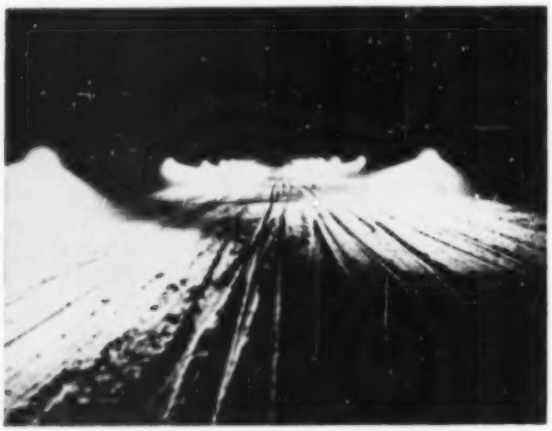

Figure 3. Low-mounted lighting study — Busse Highway, Des Plaines, Ill. — 1945.

Figure 4. Searchlight type unit used in low-mounted lighting study.

Observations and tests of all factors of both the low and high mounted systems were made by many people including highway and lighting engineers from numerous parts of the country. Measurements of pavement, obstacle and source brightness were made with a Luckiesh-Taylor precision brightness meter at various distances with the meter positioned 56 inches above the road surface. Horizontal footcandle readings were also measured with the precision meter by reading the brightness of a self leveling magnesium block. Tabulation of these and other readings were included in a report prepared by the Illumination Laboratory of the Commonwealth Edison Company and presented to the Cook County Highway Department for further study.

This report attempted to evaluate the test installation from all angles and concluded that the low mounted system did not compare favorably with the more conventional systems that had been developed over a period of years. It further summarized that when weighed against current design of high mounted units, the appearance and safety advantages of the low mounted type are greatly overbalanced by the deficiencies of illumination.

Lighting on Edens Expressway

As a result of the above studies and the development of the mercury light source, the Cook County Highway Department submitted location plans to the utility company and requested a schematic lighting layout showing available electric service location. This schematic layout contemplated using high mounted mercury vapor units

spaced approximately 100 feet apart to produce about 1.0 footcandle.

Using the suggested service locations the Cook County Highway Department submitted to the "Design Committee," which is composed of engineers from the participating agencies, City, County, State and Federal Government, plans and estimates for lighting Edens Expressway based on three schemes of lighting. The first was to light interchanges only. The second scheme was to install continuous lighting varying the illumination from 1.5 footcandles at the intersections to 0.5 footcandle midway between structures. The third and accepted proposal was continuous lighting of constant illumination meeting the Illuminating Engineering Society recommendations for "Heavy to Heaviest" Vehicular Traffic Classification with "Light or None" Pedestrian Traffic.

The lighting system on Edens will contain 1081 units when completed. The first section of this system consisting of 273 units covering a distance of about three miles was placed in service on March 12, 1953, and construction is now in progress on the remaining eleven miles of the road.

Prestressed concrete standards were selected on the basis of strength, appearance, low maintenance and initial cost and because they fit the aesthetic pattern created by the concrete bridges and ribbons of pavement. Eight-foot aluminum upsweep brackets support I.E.S. Type III luminaires enclosing 20,000-lumen E-H1 mercury lamps at a height of 32 feet above the pavement. The face of standards are set back 7 feet 6 inches from the outside edge of the pavements and 95 feet apart in a staggered arrangement along the straight-a-way. On the curved ramps leading to and from the highway, standards are placed along the outside of the curves at intervals of approximately 160 feet. (Figs. 5 and 6)

Figure 5. Mercury vapor lighting on Edens Expressway north of Chicago — 1953.

A single phase multiple system of wiring was chosen to operate at 240/480 volts with grounded neutral. Power is supplied at ten locations along the right of way. The primary line consists of #6 A.W.G., 5 kv, 2/C concentric cable installed in duct with concrete encasement from the utility pole to a precast concrete power center located near the edge of the pavement. Each power center houses a disconnect, arrester, 2400/480/240 volt transformer, metering, secondary distribution and control equipment. The connected load at each location varies from a total of 93 to 155 mercury units. (Fig. 7)

All phase wires feeding the lights are 600-volt, 1/c neoprene jacketed Type USE cable and neutral wires are bare. All cable is buried directly in the ground at a depth of 2 feet 6 inches except at road crossings where galvanized conduit is pushed under the pavement or mounted on the bridge structure. All wires are coded to easily identify a part night from an all night circuit. Pole top ballasts are

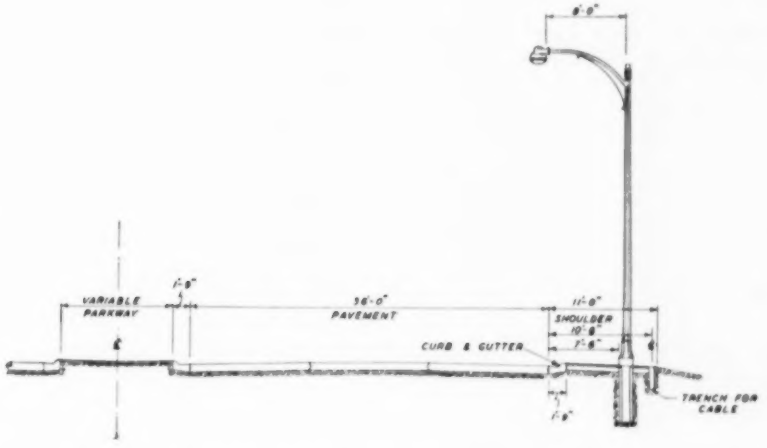

Figure 6. Typical cross-section of Edens Expressway.

Figure 7. Typical power center on Edens Expressway.

used with the primary connected to the 230-volt taps.

Lights are controlled by means of a photo electric cell and relay. When the north sky illumination falls below 1.0 footcandle, the relay causes the main mechanically held contactor to close, energizing all circuits. In series with this contactor is a second contactor controlling circuits which operate only part night. A time clock opens these part time circuits at 1:00 a.m. and closes them again at 5:00 a.m. When the sky illumination increases to 1.5 footcandles in the morning the main contactor opens all circuits. The part night circuit was installed in the interest of economy of operation, and the "off" time may be changed or eliminated entirely as dictated by actual operating experience. In any case, all of the lights on the ramps, the interchanges, and the approaches to bridges and exits remain "on" all night.

Footcandle readings were taken with a G.E. No. P13 cosine corrected meter along the center line of each lane in accordance with recommendations by the I.E.S. Committee on Testing Procedures. The average level after six weeks use is 0.837 footcandles with maximum to average ratio of 3.0 and a minimum to average ratio of 0.39 which is considerably better than the value recommended by American Standard Practice for Street and Highway Lighting. (Fig. 8)

Impact on Future Highway Construction

There is no doubt that lighting of Edens Expressway will have a far reaching influence on road construction practices in Illinois and other states. Plans for lighting Congress Street Superhighway, which is now under construction, will soon be completed and will closely follow the design of Edens. Other expressways in this Chicagoland project will also contain lighting as an integral part of their safety features.

As visitors from throughout the country drive over these lighted Illinois highways there is reason to believe they will influence similar projects in all sections of the nation.

Some day we may truthfully boast that night time driving is as safe as day time driving.

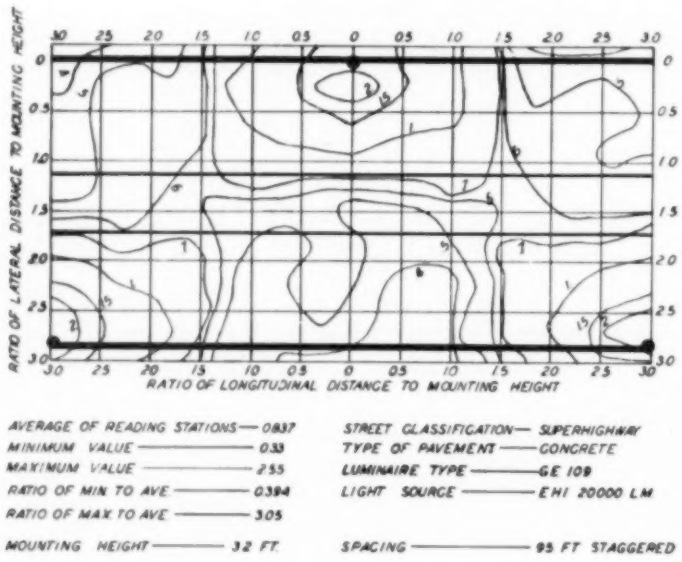
RATIO OF LATERAL DISTANCE TO MOUNTING HEIGHT
RATIO OF LONGITUDINAL DISTANCE TO MOUNTING HEIGHT
30 25 20 15 10 05 0 05 10 15 20 25 30
0 05 10 15 20 25 30

Figure 8. Isolux curve developed from horizontal footcandle readings taken on Edens Expressway.

AVERAGE OF READING STATIONS	0837	STREET CLASSIFICATION	SUPERHIGHWAY
MINIMUM VALUE	033	TYPE OF PAVEMENT	CONCRETE
MAXIMUM VALUE	255	LUMINAIRE TYPE	GE 109
RATIO OF MIN TO AVE	0394	LIGHT SOURCE	EHI 20000 LM
RATIO OF MAX TO AVE	305		
MOUNTING HEIGHT	32 FT	SPACING	95 FT STAGGERED

Comparative Rating Guide for Fluorescent Lighting Fixtures

By L. V. JAMES

THE PURPOSE of this Rating Guide is to assist in the evaluation, on a comparative or relative basis, of "plus value" features of luminaires employing fluorescent lamps, on which equipment quotations have been regularly received and which have qualified under the General Specifications distributed with the Request for Quotations. This evaluation is expressed in "Weighted Relative Cost" as herein described. The report of the Rating Committee to the Committee on Buildings shall list all lighting fixtures for which the values of "WRC" are not more than 5 per cent above the lowest such value for fixtures in the group being rated. The recommendation for purchase will be made from this list, based on these values of "WRC" and on service and other consideration. It should be noted that this Guide can also be used for luminaires employing incandescent lamps, in so far as determining values of C and F are concerned, but with some revision in the determination of R.

The Specification

A lighting fixture, to qualify for itself and for all of its parts with reference to which the Underwriter's Laboratory has ruled, shall bear the UL label to indicate approved construction and operation under those rules. Accessories used shall bear the ETL label to indicate that they satisfy the lamp manufacturers' requirements for the proper operation of the lamps or tubes for which the fixtures are designed. Each fixture must also comply with the specification details attached to the Request for Quotation, which follow the suggestions indicated in Appendix A of the Guide.

Required Information

In order to appraise any fixture under this Guide, it is necessary that a complete and accurate description of the fixture be available, with documented authority *in each instance* for claimed performance results. The following authentic information is therefore required for the operation of the Guide and must accompany each bid. If any

AUTHOR: Illuminating Engineering Consultant, La Grange, Illinois.

About the Guide

It is frequently desirable to be able to compare or rate luminaires of similar design for the purpose of evaluating their relative values. Such evaluation is especially desirable when several quotations are being considered, particularly by a public body, on equipment conforming to the architect's general specifications. A Comparative Rating Guide for Fluorescent Lighting Fixtures, prepared for this purpose, is given here in complete detail, including implementing appendixes. Its object is to offer impartial assistance in evaluating lighting performance and other important factors in fluorescent equipment considered for installation.

The details of this Guide were originally established by the author in close collaboration with the late Samuel J. Sutherland, Architect and Chief of the Construction Division of the Board of School Directors of Milwaukee. Advisory aid was obtained from many fixture manufacturers' engineers. Mr. James reports that the procedure has been tested in Milwaukee, with remarkable success. Whether other School Boards, not having their experience in the development of the Guide will be equally benefited remains to be seen. The author invites analysis and suggestions.

In the use of the Guide, it should be noted that all fixtures having within five per cent of the lowest Weighted Relative Cost are reported to the Board. This is because in some cases other considerations than relative fixture quality and performance may influence the award of the contract.

It should also be noted that, in all details, relative rather than specific values are obtained. Attention should be called to the unique methods of allowing for cleaning and other details in computing the relative maintenance factors and in allowing credit for vertical illumination in calculating relative footcandles.

"True value" is determined by computing Weighted Relative Costs per relative footcandle of light in a typical room (including wiring costs) divided by a relative rating established by the construction, appearance and brightness control characteristics of the fixtures.

Reprints of this complete Guide may be ordered in quantity through the Publications Office, I.E.S. Headquarters.

such required information is not furnished at the time stated for the opening of the bids, the fixture cannot be considered as having qualified under the Specifications. Catalogue or other published material may be used *provided that specific reference to page and location on the page is clearly stated*, and that the information is immediately available therein without further analysis and computation.

1. *Complete Construction Details*—dimensioned drawings accompanied by a complete description, giving the size of all details, the nature of all parts and the method of their assembly. Thickness of materials, etc., as observed, will be checked against this information. See G1-A, B, C, D and E and G2-C for information as to the coverage needed.

2. *Complete Photometric Report* — prepared by a recognized disinterested laboratory acceptable to the purchaser, showing the rating of the lamp used in the test; candlepower distribution curves (normal to, at 45° with, and in line with the lamp axis); zonal and total lumen output values; maximum brightness values in the zones indicated in *Q*1, *Q*2 and *Q*3 (zones 0° - 30°, 30° - 45° and 45° - 90°, crosswise and lengthwise), or data from which such brightness values can be determined (the supplier or manufacturer may offer suggestions for such determinations but must recognize that the Board's interpretation will prevail). The maximum brightness value shall be the average of the brightest inch square.

   A table of coefficient of utilization values for customary rooms, including a room with an "E" room index, shall accompany this report. If this table has been prepared by other than the disinterested laboratory referred to, it shall be accompanied by a sample calculation indicating how the laboratory data have been used to derive the values in the table.

3. *List of Accessories* to be furnished with the fixtures—by manufacturer's name and model number, with such details as watts loss in ballasts, etc.

4. *Any Additional Information* which the supplier or manufacturer feels would assist the purchaser in his analysis of the merits of the bid fixture.

5. To facilitate furnishing the above information, a "Fixture Description Form" is shown in Appendix B. Separate copies are available for use by bidders.

Sample Luminaire

The Board shall be supplied with a sample of the bid fixture, free of charge, not later than the time specified for the opening of the bid, in one of two ways, as follows:

1. The proposal may require delivery of the sample with the bid, or
2. The proposal may require an open order executed by the manufacturer, reserving the right to the Board in its discretion to have its representative make a free selection of this sample from open stock of in the custody of any supplier, locally or elsewhere.

The sample of the successful bidder shall be retained and credited toward the delivery of the order. All samples of unsuccessful bidders shall be available to them for repossessing when the contract shall have been awarded.

The Board also reserves the right to require that the model bid and the sample furnished be a standard model, catalogued by the manufacturer and established in production, and that the facilities for manufacturing same (unless the quantity being ordered is available and the order is to be filled from stock) shall be adequate for the prompt production of the fixtures as required by the specifications. This shall be demonstrated to the satisfaction of the personnel responsible for making recommendations with respect to the purchase of lighting fixtures by the Board, should such personnel so require.

Fixtures delivered under the contract shall be identical in construction and performance to the evaluated sample. Should there be a question in the minds of the aforementioned Board personnel as to whether this is the case, the right is reserved to have a photometric test made on the sample or on the delivered fixture. In presenting his quotation, the bidder or contractor hereby agrees that he will bear the cost of such a test should the results not check closely those submitted. Should the results check, the cost for the test will be borne by the Board.

Comparative Rating Determination

Comparative Rating values are determined in the following manner: The Total Relative Annual Cost per Relative Average Maintained Footcandle is computed for a representative room,* for each fixture, and this cost is then divided by a Relative Rating Factor, determined by the general characteristics of the fixture and the quality of the light-

*NOTE: Lighting Fixtures will be purchased (a) for certain rooms or (b) for stock.
If (a), *C* and *F* values are determined for these rooms. (The number of fixtures fitting the room will vary for different fixtures, but the number used must be such that it can deliver an average foocandle level, maintained, of the order desired.)
If (b), *C* and *F* values are determined for a room typical of those where the fixtures are likely to be used. (Note conditions as in (a).)

ing delivered by it. The result is the Weighted Relative Cost, on the basis of which the recommendation for purchase is made.

Thus, $WRC = \dfrac{C/F}{R}$ (C over F, divided by R)

where

C is the Relative Annual Cost of Light for a Typical Room where Fixture is to be used,

F is the Relative Mean Average Footcandles Delivered in Service, so C/F is the Relative Annual Cost per Relative Mean Average Footcandle in Service, and

R is the Relative Rating Factor for the Fixture, and is $G \times Q$. Here

G is the Relative Rating Factor for General Characteristics, and

Q is the Relative Rating Factor for Lighting Quality.

Derivation of Relative Mean Average Footcandles in Service

F (Relative Mean Average Footcandles Delivered in Service) is computed from the characteristics of the typical room where the fixtures are to be used, qualified for distribution, and is

$$\frac{N \times L \times CU \times RMF}{A} \times DF$$

where

N is the Number of Fixtures Required in the Room

1. in a suitable arrangement, such that it could maintain approximately the desirable footcandle level, computations being made using either manufacturer's design factors or derived factors, or
2. according to the architect's drawings and specifications.

L is Rated Initial Lamp Lumens per Fixture and is the Value given by Lamp Manufacturers. (Where fixtures of different sizes are used in a room, accumulate $N \times L$ values to obtain the total initial lamp lumens for the room.) Note that, for fluorescent lamps, rated initial lumens are after 100 hours burning.

CU is Coefficient of Utilization for the Fixture Type and Room, and is obtained directly from the photometric report or is computed from the lumen distribution data in that report, for the selected dimensions and decoration of room. (See Appendix D and No. 2 Rating Record Card for method of computation.)

RMF is Relative Maintenance Factor, for the Fixture and Room, as derived below.

A is Floor Area of Typical Room, in square feet.

DF is a qualifying factor for footcandle distribution, and is $1/(2 \times$ the "Flux Ratio" for the direct component), except that no value of DF shall exceed unity.

(See Appendix D, and No. 2 Rating Record Card, for "Flux Ratio.")

Determination of Relative Maintenance Factor

MF (Maintenance Factor) is that factor by which the initial footcandles (average in room) is multiplied to get the mean value of those footcandles maintained in service, throughout the life of the installation. MF can be determined accurately only by a prolonged test (perhaps lasting several years) in the particular room and environment where the fixtures are used.

RMF (Relative Maintenance Factor) is a derived substitute for MF for comparative rating purposes, based on photometric and other test data furnished by the manufacturer, on room data assumed alike for all fixtures, on inspection of the fixture for soil collecting characteristics and on test and other information furnished by the purchaser.

RMF is $RMF_a \times RMF_b \times RMF_c \times RMF_d$

where

RMF_a represents the decrease in light due to lamp depreciation and is here presumed to be the per cent "mean lumens" output of the lamp expressed in decimal form, furnished by the lamp manufacturer.

RMF_b represents the decrease in light output of the fixture due to soil on lamp and fixture surfaces, adjusted for relative cleaning periods on an equal annual cost basis. The amount of this soil accumulation depends on

1. Type of fixture,
2. Portion of light output of lamp intercepted by soiled surfaces,
3. Accumulation of soil on fixture surfaces, and
4. Cleaning cost or ease.

In the attached table, the nature of light distribution as determined from the photometric data, submitted by the manufacturers,

Table of Data To Assist in Deriving Values of RMF_b

Type of Lighting Fixture	Nature of Distribution % Up, % Down	Relative Basic Factor	Limiting Variation, from Inspection Influence of Air Flow	Position	Nature
Direct and Semi-Direct	0 & 100 to 40 & 60	.15	.05*	.05*	.03*
General Diffusing	40 & 60 to 60 & 40	.20	.07*	.07*	.04*
Semi-Indirect and Indirect	60 & 40 to 100 & 0	.25	.07*	.07*	.04*

*Plus or minus.

indicates the fixture classifications. (See Appendix F.) For each such classification, a relative basic factor is given which represents an approximation of the relative average reduction in lighting effectiveness for that fixture type, considering the normal portion of light intercepted by fixture surfaces and the average depreciation of these surfaces.

Such relative basic factors, for the group of fixtures under consideration, are now qualified by varying them up or down, arbitrarily, within the limits indicated, depending on the probable relative effect of the soil on lamp and fixture surfaces, as influenced by air flow, by the position of the surfaces from vertical to horizontal above or below the lamps, by the nature or character of the surfaces, and by any unusual variation in the amount of free or un-intercepted light from the lamps. Where some light is transmitted through a surface, the part of the light so transmitted is affected by soil accumulation on both sides of the surface, the average influence of the two being used. The relative amounts of each of these influences is estimated from an inspection of the fixtures.

The influence of relative cost or ease of cleaning is introduced here by multiplying the final values of these qualified basic factors, as derived, by factors representing the relative cleaning periods (periods established on the basis of the same cleaning cost, referred to the longest of such periods as unity), and then these altered depreciation values are subtracted from unity to obtain the final values for RMF_b. (See Appendix D.)

RMF_c is 1.00 minus the decrease in light output due to deterioration of fixture surfaces, based on local experience, on simple field tests and on guaranteed and prover performance information submitted by the fixture manufacturer.

RMF_d represents the influence of room soil on illumination. To obtain the value of this influence, the coefficient of utilization is noted for clean conditions (perhaps 75-50 reflectances) in a representative room, probably E, and then for soiled conditions (perhaps 50-30 reflectances). Considering the cleaning and decorating schedule, etc., a part of this decrease is used to represent the probable influence of room soil and this part, divided by the 75-50 value, is RMF_d. The same relative part of the decrease is used for all fixtures being compared.

Derivation of Annual Cost of Light

C (Annual Cost of Light for a Typical Room where Fixtures are to be Used) is $C1 + C2$

where

$C1$ is Annual Cost of Lighting Installation, per Year of Nominal Life, and

$C2$ is Annual Cost of Lighting Operation.

$C1$ (Annual Cost of Lighting Installation, per Year of Nominal Life, See Appendix D) is

$$\frac{C1\text{-}A}{Y}$$

where

$C1\text{-}A$ is total cost of lighting installation, and

Y is nominal life of lighting installation in years.

$C1\text{-}A$ is $C1\text{-}A1 + C1\text{-}A2 + C1\text{-}A3 +$ or $- C1\text{-}A4$

where

$C1\text{-}A1$ is cost of N* fixtures installed, including assembly and wiring of fixtures and of connecting these to room wiring, but exclusive of lamps. Ease of installation will be considered here. (See Appendix D.)

$C1\text{-}A2$ is complete cost of wiring from cabinet to and including room ceiling outlets and switches, for N fixtures. (See Appendix D.)

$C1\text{-}A3$ is complete cost of building wiring to and including distribution cabinet, for room (for service to lighting fixtures only). (See Appendix D.)

$C1\text{-}A4$ is incidental cost or credit in arranging for lighting installation, such as structural work required at ceiling.

Y (Nominal Life of Installation in Years) is assumed to be 10 years (Building wiring would have longer life than other elements but, in the interest of simplicity, the same figure is used throughout.)

Thus $C1$ is $(C1\text{-}A)/10$.

$C2$ (Annual Cost of Lighting Operation) is

$C2\text{-}A + C2\text{-}B + C2\text{-}C$

where

$C2\text{-}A$ is the annual cost of electrical energy for lighting the room with N fixtures, and is the total kilowatts per room for lamps and ballasts, times 1000 hours estimated average use per year, times the estimated average rate per kw hr. throughout the year, including the demand charge if any. (See Appendix D.)

$C2\text{-}B$ is the annual net cost of lamp and starter replacements for N fixtures. For lamps this is the number of lamps in the room, times the net

*N is number of fixtures selected. Dividing results later by F footcandles will reduce all computations to a common basis.

NOTE: Fixture costs in C1-A will be obtained from firm quotations in the bid or electrical contract, from published net prices to consumers. Estimates of related installation and wiring costs are added. (See Appendix D.)

price each plus ———* cents each for labor, times 1000 hours estimated average use per year; divided by the rated average lamp life for the operating conditions (considering here the average number of burning hours per start, for fluorescent lamps). If starters are used, assume one starter replacement for each lamp replacement, except where starters are designed to turn lamps off when they start to flicker. In that case, assume one starter life equal to three lamp lives. (Starter life is a function of number of starting attempts, flicker plus starts, and may equal that of several lamps where burning hours per start are long and non-flicker starters are used.)

C2-C is the annual expense for replacement of parts for *N* fixtures exclusive of lamps and starters but including ballasts, lamp holders and fixture parts, plus estimated cost of repairs, all based on the experience of the Repair Division for the type of fixture involved. (See Appendix D.)

Derivation of Relative Rating Factor

R (Relative Lighting Fixture Rating Factor, by means of which credit is allowed or penalty applied on the basis of relative construction and appearance and of relative quality of lighting) is $G \times Q$

where

G is Relative Rating Factor for General Characteristics and is the Total of Relative Rating Points in *G* Rating Check List divided by 16,000 and

Q is Relative Rating Factor for Lighting Quality and is the Total of Relative Rating Points in *Q* Rating Check List divided by 10,000.

Rating Check Lists

NOTE: In the following evaluations, "bogey" points indicated for any classification may be decreased by penalties. In extreme cases, the rating committee may exact a greater penalty than that shown or, when comparing to a Standard, may allow a bonus. High ratings establish superior construction and performance and result in lower and therefore more favorable Weighted Relative Costs.

The General Specifications accompanying the Request for Quotations *must be depended on to eliminate any entirely unsatisfactory fixtures*, the rating procedure indicating only the relative weight to be given "plus values" in the several categories. Particularly see the paragraph in Appendix A on safe construction. There can be nothing "relative" between an unsafe fixture and one that is safe, but there can be "plus" features as between various safe fixtures.

"G" Rating Check List for Relative Rating Points for General Characteristics

(Bogey: 10,000 points)

See Appendix D for reduced "G" bogies where fixtures are included in a general construction proposal.

G is G1 + G2 where

G1 pertains to Fixture Construction	Bogey 5500 points
G2 pertains to Fixture Appearance	Bogey 4500 points

G1 pertaining to Construction Bogey 5500 points

is G1-A + G1-B + G1-C + G1-D + G1-E

where

G1-A pertains to Mechanical and Electrical Safety	Bogey 2000 points
G1-B pertains to Mechanical Installation	Bogey 1000 points
G1-C pertains to Electrical Installation and Accessories	Bogey 700 points
G1-D pertains to Replacement of Parts	Bogey 600 points
G1-E pertains to Cleaning	Bogey 1200 points

G1-A Concerning Mechanical and Electrical Safety Bogey 2000 points

Mechanical: Maximum safety might be assumed to exist when an all metal indirect fixture is assembled solidly, lamps alone being removable and these supported should they become detached. Minor deductions are made for the presence of any possible hazardous part; a greater deduction for less secure attachment, as follows:

	Penalty
1. Glass—presence of (—50), security of	(to —300)
2. Plastic—presence of (—30), security of	(to —100)
3. Detachable louver assembly or individual louvers, presence of (—100), security of	(to —300)
4. Detachable fixture parts, presence of (—50), security of	(to—300)
5. Lack of support for possible detached bi-pin lamp	(to —60)
6. Lack of support for possible detached single-pin lamp	(to —40)
7. Rigidity and security of lamp holders	(to —200)
8. Hanger construction and attachment method	(to —300)
9. Treatment of edges	(to —100)

Electrical: Underwriters' Laboratory approval indicates safe fixture wiring and assembly. Only penalty is for high voltage in wiring outside of fixtures.

10. Service voltage required to fixture	(to —100)

G1-B Concerning Mechanical Installation Bogey 1000 points (including facilities for alignment, coupling, hanging, conditions required from others, etc., from "nuisance" rather than "economy" standpoint.)

	Penalty
1. Hanger construction from standpoint of ease of mounting	(to —100)

*Cost of labor per replacement to be based on experience of the Plant Operation Division for the type of lamp and fixture used. No additional labor is needed for the starter. (See Appendix D.)

2. Ease of attaching fixture chassis ..... (to −100)
3. Parts other than chassis to accumulate and attach ..... (to −100)
4. Lateral and Vertical alignment facility ..... (to −200)
5. Ease of coupling to adjacent fixtures ..... (to−100)
6. Other work affected—ceiling structure, etc. (to−100)
7. Relative fixture weight per support—consider also N.E.C. (4132) limit of 50 lbs. per support from outlet box ..... (to −200)

Caution: Local electrical code requirements affecting construction and/or installation method must be met. For example, recessed fixtures may require special installation involving fire-proofing materials.

G1-C Concerning Accessories, Fixture Wiring and Electrical Installation ..... Bogey 700 points

Penalty

1. Type and size of fixture wire used ..... (to −100)
2. Type of wire splices in fixture and number of splices required to and between fixtures ..... (to −100)
3. Rated noise of ballasts ..... (to −100)
4. If starters employed (See C2C):
   A. No-blink cut-out types ..... (to −50)
   B. Other types ..... (to −100)
5. Holder construction and mounting to make secure electrical contact ..... (to −100)
6. Room wiring required ..... (to −100)

G1-D Concerning Replacement of Parts from "Nuisance" Rather than "Economy" Standpoint ..... Bogey 600 points

Penalty

1. Accessibility of Parts for replacement (ballasts to −50, lamps, starters, holders, fixture parts, etc. to −150) ..... (to −200)
2. Lamp holder durability ..... (to −100)
3. Ballast Durability ..... (to −100)
4. Lamp types from standpoint of others stored at same place ..... (to −100)

G1-E Concerning Cleaning from "Nuisance" Rather than "Economy" Standpoint ..... Bogey 1200 points

Penalty

1. Presence of louvers or baffles ..... (to −100)
2. Louver size (with reference to number to be cleaned and possible hand insertion) ..... (to −100)
3. Ease of suspending and of removing louvers ..... (to −200)
4. Other fixture parts necessary to be removed for cleaning ..... (to −100)
5. Easily cleanable surfaces. Note possible presence and accessibility of glass and plastic for cleaning ..... (to −300)
6. If opaque or diffusing media is below lamps, accessibility of same for cleaning ..... (to −200)

G2 Appearance ..... Bogey 4500 points

is G2-A + G2-B + G2-C

where

G2-A pertains to Suitability for Architectural and Use Character of Room ..... Bogey 2000 points

G2-B pertains to Other Fixtures in Building ..... Bogey 1000 points

G2-C pertains to Permanence of Shape and Appearance ..... Bogey 1500 points

G2-A Suitability for Architectural and Use Character of Room and Building where to be Installed ..... Bogey 2000 points

(The purpose of this requirement is obvious—rating to be determined by School Board Architect)

G2-B With Relation to Other Fixtures for Similar Lighting in Rest of Building ..... Bogey 1000 points

(Same comments as for G2-A)

G2-C Affecting Permanence of Shape and Appearance ..... Bogey 1500 points

Penalty

1. Weight and configuration of metal ..... (to −200)
2. Weight and construction of louvers ..... (to −200)
3. Installation of louvers (including end attachment) ..... (to −200)
4. Weight and configuration of plastic to resist warping ..... (to −200)
5. Nature of plastic to resist discoloration ..... (to −150)
6. Odd glass parts difficult to replace ..... (to −200)
7. Durability of finishes on all surfaces, due to nature and application of finish ..... (to −100)
8. Other fixture details affecting possible change in shape and appearance ..... (to −100)

"Q" Rating Check List for Relative Rating Points for Lighting Quality

(Bogey: 10,000 points)

Q is Q1 + Q2 + Q3 where

Q1 pertains to Maximum Fixture Brightnesses as Seen,

Q2 pertains to Fixture Brightness Causing Veiling Glare at the Work and

Q3 pertains to Ceiling Brightness, as Seen.

Lighting quality is largely obtained by limiting variations in the visual brightness pattern throughout the room. Excessive variations in the specific field of the task prevent good visibility (excessive levels of illumination in footcandles at this point are scarcely possible with artificial lighting), while excessive brightness variations in the general visual field cause discomfort and interfere with the best eye adjustment for the work.

Variations at the task are due mostly to reflections, in task material, of high downward fixture brightnesses (in calendered paper, desk surface, etc.), and is here considered in Q2. Brightness variations in the general visual field are usually due to high fixture and ceiling brightnesses, as seen, or to a high contrast between fixtures and ceiling, and are here considered in Q1 and Q3.

Unequal distribution of light from the lighting installation, resulting in variations in footcandle levels at the work and in reduced levels at points on vertical surfaces, is a matter of proper installation planning plus fixture selection. Good visual environment also may require that chalkboards, maps, demonstrations, etc., be well lighted. But these are not necessarily the responsibility of the general lighting fixtures.

While various leaders among illuminating engineers have evolved interesting methods for evaluating these quality conditions, the only officially approved standards are the brightness ratios and the limiting maximum brightnesses given in the American Standard Practice for School Lighting A23.1-1948, upon which the requirements in Q1, Q2 and Q3 are based. The possibility is recognized that, at some future date, these standards will be revised and made more complete, at which time a corresponding revision of these quality factors will be in order.

Q1 (pertaining to Maximum Brightnesses of Fixtures as Seen) ..... Bogey 6000 points

is Q1-A + Q1-B

where

Q1-A pertains to Brightnesses in the Zone 0°-30° below Horizontal, and

Q1-B pertains to Brightnesses in the Zone 30°-45° below Horizontal.

Q1-A Maximum Fixture Brightnesses in Zone 0°-30° below Horizontal Related to 450 Footlamberts

1. Lengthwise of room ..... Bogey 2400* points
2. Crosswise of room ..... Bogey 1600* points

Q1-B Maximum Fixture Brightnesses in Zone 30°-45° below Horizontal Related to 900 Footlamberts

1. Lengthwise of room ..... Bogey 1200* points
2. Crosswise of room ..... Bogey 800* points

Q2 Maximum Brightness in Zone 45°-90° below Horizontal, Related to 2000 Footlamberts, Lengthwise or Crosswise ..... Bogey 2000* points

Q3 Maximum Brightness of Diffuse Ceiling, of 80% Reflectance, at Specified Mounting, Related to 450 Footlamberts and Qualified for Distribution of Ceiling Brightness** ..... Bogey 2000* points

*Maximum brightnesses in these zones are preferably obtained directly or interpolated from photometric reports submitted by the manufacturer, corrected for current lumen output of lamps, if necessary; if not available then from observation on test. In the latter case, it should be understood that the lamp is a part of the fixture for the purpose of this test and, if exposed even in part, must be considered. Maximum brightness is here intended to be the average brightness of that inch square (projected) of fixture (and lamp) which has the highest value in the given zone.

Such maximum values are divided into the reference value and the quotient so obtained is multiplied by the Bogey points to get the Rating.

An *upper limit* for this *rating* shall be *double the Bogey;* no lower limit is needed.

Thus:

If observed maximum brightness, Q1-A1, is 400, 450/400 × 2400 is 2700 points.

If this brightness is 600, 450/600 × 2400 is 1800 points.

If this brightness is 200, 450/200 × 2400 is 5400 — allow 4000 points.

**The ceiling brightness data required for Q3 should always be given in photometric test reports for ceiling-mounted or close suspension fixtures. Ceiling brightnesses above *suspended* open top fixtures, whose lamps are at least 12 in. from the ceiling, are unlikely to exceed 225 footlamberts. If not given in the photometric report, a local check test can be made, but this involves maintaining a constant voltage and temperature and using rated lamps or at least the same lamps for all fixtures. It is therefore recommended that full credit of 4000 points be given for such suspended fixtures, as probably would be found due, unless such test facilities are readily available.

Exposed fixtures (ceiling mounted, or suspended) emitting no light to the ceiling will be classified for Q3 according to the number of lamps per fixture — one lamp, 2000 points; two lamps, 1200 points; three lamps, 500 points; four lamps or more, no points. The dark tops of troffers are not visible and these will be rated 1000 points above the corresponding point values for closed-top exposed fixtures for the same number of lamps per fixture.

Appendix A — The Specification

(For information of the Specification writer)

A partial list of items which should be included, in addition to any other desired requirements, in the specifications attached to the Request for Quotations.

Type of fixture — indirect, direct, general diffusing, etc.

Whether it is to be pendent, surface or recessed mounting.

Limiting dimensions, length and width, if any.

Nature of material required in construction if preferred — reflecting surfaces, louvers, canopies, etc.

Minimum shielding angles, transverse and lengthwise of fixture.

Type and number of lamps for which designed (bid with and without lamps if purchaser desires).

Type of ballast (including power factor and noise rating), lamp holders and starters, if any preferred.

Whether mounting is to be singly or in rows, with number of each in latter case.

Length and number of stems per fixture or row.

That fixture and hanger must be well and safely constructed and that the weight of material used in critical parts must be adequate from the standpoint of safety and permanence.

That a complete sample, without lamps, must be submitted as required in specifications of the Guide. That this sample must be equipped with its hanger or hangers required for the type of mounting specified. Since the fixture will be suspended by itself for inspection, an additional hanger may be needed for that purpose.

That a complete photometric test report is required, applying to the specific fixture as submitted and prepared by a recognized disinterested laboratory acceptable to the Board, as stated under "Required Information" of this Guide.

That all of the information indicated on the Fixture Description Form (Appendix B) must be submitted with the bid (or separately before the time stated for the opening of the bids, then to be plainly marked as to the fixture covered and the name or names of the bidders), the information being provided in accordance with the instructions on the Form. The specifications should note particularly that data on fixture brightnesses in all zones (and on ceiling brightnesses for surface mounted fixtures), required in Section 5 (f) to (n) inclusive on the Form, must be given.

That, if the sample and information described above are furnished by the manufacturer or by one bidder, for several bidding on that fixture, the manufacturer or manufacturer's representative must so advise by the time the bids are to be opened.

That, where more than one type of fixture is offered, the quoted price must be separated for the several types, such that each can be considered alone.

That the fixtures offered and accepted for rating will be evaluated by a rating committee by means of a physical inspection and by an examination of the information furnished (see Specification Section), including a determination of the Weighted Relative Costs.

That there is attached to the Specification a copy of the Request for Quotations and a copy of the Preface and Specification Sections, also two copies of the Fixture De-

scription Form (Appendix B) for each fixture type specified. That one of these Fixture Description Forms must be completed *for each fixture* and returned with the Quotation. That a copy of the complete Comparative Rating Guide is obtainable, if desired, on request to the Construction Division.

Note to Specification Writer: It is desirable that purchase contracts for stock, or for fixtures to be installed by Board employees in existing buildings, be placed on a period basis, provision being made for a quantity to be taken during that period, in some cases to be used after that period, thus reducing the frequency of ratings.

Appendix B — Fixture Description Form For Fluorescent Lighting Fixture Comparative Rating Guide

(To be filled in by bidder)

Note: This Form is part of the Quotation. Delivered fixtures must conform to information given. Use a separate form for each different fixture offered. *Fill in each blank or indicate there* where the information required is available in any catalogue or other material attached, *marking that information* plainly with the number and letter (such as 2a) given to the detail on this form. *Failure to give the information required* will constitute *failure to comply with the specifications* and will, therefore, *result in an automatic rejection of the bid* for that particular fixture.

The purpose of this Form is to call attention to important fixture details as well as to secure information about them.

1. *General Information:*

Bidder's name and address (a)_____
Name and catalog number of fixture (b)_____
Manufacturer's name (c)_____ Address (d)_____
Lamp type and number of same for which designed (e)_____
Is fixture a standard model of manufacturer, established in production (f) _____
Could order for quantity required be furnished expeditiously (g) _____
Additional remarks (h)_____
_____

2. *Fixture Construction:*

Literature or statement explaining attachment of detachable parts (a)_____
Accessories which will be furnished, by name of manufacturer and model number: Ballast (also watts and power factor) (b) _____
Starters (c)_____ Holders (d)_____
Are all accessories ETL approved? (e)_____
Are fixture parts and complete fixture UL approved? (f)_____
_____
Type and size of fixture wire used (g)_____
Type of wire splices (h)_____
Give ballast rating for noise (i)_____
Literature or statement explaining accessibility of parts for cleaning or for replacement (j)_____
Dimensions of fixture without hanger — Length (k)_____
Width (l)_____ Height (m)_____
Weight of fixture with hangers (n)_____
Thickness of metal used: Channel (o)_____
Reflectors (p)_____ Louvers (q)_____
Stem size and wall thickness (r)_____
Louver dimensions: Spacing lengthwise of fixture (s)_____
Spacing crosswise of fixture (t)_____
Height at lamp (u)_____
Information on coupling and installation of fixture (v)_____
_____
Dimensioned sectional sketch or print: Crosswise (w)_____
_____ Lengthwise (x)_____
Additional remarks (y)_____
_____

3. *Fixture Finish:* (Complete information on finishing method may be attached)

Finish of metal reflector surface: Preparation of metal (a) _____ Finish of surface (b) _____
Finish of channel above lamps: Preparation of surface (c) _____ Finish of surface (d)_____
Finish of louvers: Preparation of surface (e)_____
Finish of surface (f)_____
Exterior finish of fixture (g)_____
Of hanger (h)_____ Of canopy (i)_____
Full information on glass used: Trade name (j)_____
_____ Thickness (k)_____
Full information on plastic used: Trade name (l)_____
Thickness (m)_____ Permanence of shape (n)_____
Permanence of color (o)_____
Additional remarks (p)_____
_____

4. *Hangers:*

Literature or statement on alignment: Lateral (a)_____
Vertical (b)_____
Strength information (c)_____
Further information on hanger (d)_____
Additional remarks (e)_____
_____

5. *Lighting Properties and Photometric Test Report:*

Candlepower distribution curves: Transverse (a)_____
Parallel (b)_____ 45° diagonal (c)_____ Zonal lumens (d)_____ Made by (e)_____
Maximum fixture brightnesses, including lamp as exposed (required to be average brightness of brightest inch square in zone): 0-30° zone, lengthwise of fixture (f)_____, crosswise of fixture (g)_____; 30-45° zone, lengthwise of fixture (h)_____, crosswise of fixture (i)_____; 45-90° zone, (j)_____ how measured (k)_____
_____ Test by (l)_____
of _____
Note: If any of these brightness values are not given, the committee may endeavor to estimate same from the information furnished — for instance by using the brightness at 90° if it is obvious that the lamp is exposed. Such estimates should not be necessary and their use is not assured.
Maximum ceiling brightness for surface mounted fixtures (see Q3) (m)_____
Test by (n)_____
Coefficients of Utilization: E room for 75-50 surfaces (o)
_____
E room for 50-30 surfaces (p)_____
Computed by (q)_____
Lumens of test lamp used in photometric tests (r)_____
Shielding angles: Crosswise of fixture (s)_____
Lengthwise of fixture (t)_____
How determined (u) _____
Note: If the Coefficient of Utilization Values are not computed by the "disinterested laboratory," a sample calculation is required.
Additional remarks (v)_____
_____

Appendix C — Procedure

(For information of Rating Committee)

Quotations will have been requested on fixtures in accordance with specifications which prescribe minimum construction and accessory details and which require both full material and photometric information and also delivery of a fixture sample. This request will have been accompanied by a copy of the lighting fixture specifications, by a copy of the Preface and Specification sections and by two copies of the Fixture Description Form (Appendix B) for each fixture on which a quotation is requested, one of these fixture description form copies to be completed and submitted with the bid.

As soon as the bids have been opened, the fixture sample and the information required with the bid is to be checked and, if any of this does not conform in any particular with what is required, the bid shall be rejected.

The bidder is to be advised as to the reason for the rejection. Details:

1. Purchasing Office determines if quotations are in order.
2. Is sample furnished as required?
3. Is the required information furnished? Information is listed on the Fixture Description Form and may be given there or by reference there to other material. It *must* include a complete photometric report, prepared by a disinterested laboratory, applying to the bid fixture.
4. If the answer to 1, 2 *or* 3 is negative, reject quotation and advise the bidder as to the reason, directing him to pick up his sample fixture.

Prior to the called meeting of the rating committee, the samples of the accepted fixtures are to be unpacked carefully, the method of packing being noted so the fixtures can be repacked properly if they are to be repossessed later, and the fixtures are to be mounted in the inspection area under the supervision of a committee member, each fixture being marked to indicate the bidder supplying same and also the manufacturer. All details pertaining to the assembly and hanging of the fixtures are to be noted carefully, so these can be explained and demonstrated later to the entire committee. Lamps need not be installed nor the wiring connected. If any sample is incomplete it should be repacked and the quotation rejected, advising the bidder.

Also prior to the called meeting of the rating committee, the values of *F*, *C* and *Q* in the Guide are to be computed, full details being listed on the Rating Record Cards, so these values can be explained and demonstrated to the committee. In order to make these computations, the probable number and arrangement of each of the fixture models, for the typical room, must be established and the following conditions and values determined for each fixture offered. (See Appendix D for information.)

Probable relative time and expense required for cleaning, for MF_b.

Probable relative surface deterioration, for MF_c.

Probable proportional depreciation of room surface reflectances, from 75-50 toward 50-30, for MF_d.

Total watts and number of circuits to room.

Number of ceiling and switch outlets required.

Cost per room of C1-A1, C1-A2, C1-A3 and C1-A4. (Connecting fixtures to room outlets may be included in C1-A1.

Rate per kw. hr. for computation of C2-A.

Cost of lamp replacement for C2-B.

Estimated cost of repairs per room, for C2-C.

Also prior to the meeting of the rating committee, information about the accepted fixture is to be listed on the No. 1 Rating Record Card.

All members of the rating committee (personally or by representatives as authorized in their appointments) shall agree upon the relative values of the fixture characteristics listed under *G* in the Comparative Rating Guide and these values shall be recorded on the Rating Record Cards. They will also check the computations of *F*, *C* and *Q* and supervise the final calculation of *WRC*, the Weighted Relative Cost, for each fixture. All observations and computations for fixtures, for which the *WRC* values are at all close to the lowest value, will be carefully re-checked, perhaps by machine.

A report, giving the recommendations of the Rating Committee, will be submitted to the Committee on Buildings of the Board by the Chairman. This report will be endorsed by all the committee members. An abbreviated resumé of the details of the rating observations and computations will be attached to this recommendation, or given to the Building Committee orally, as they may direct. A copy of the recommendation as reported and of the abbreviated resumé will be given to the rating committee members.

The rating committee above referred to (as organized in Milwaukee) shall consist of an illuminating engineering consultant (technical adviser); an illuminating engineer from the power company (representing the local public utility); the Superintendent of School Buildings, Maintenance and Repair, or his representative*; the Supervising School Engineer, or his representative*; and the Chief of the Construction Division, or his representative,* who will act as chairman. Each member of this committee shall automatically receive a copy of the Request for Quotations and attached Specifications when these are sent to prospective bidders.

"G" Rating Standard: Where fixtures are likely to be rated frequently, it is desirable that one of each type be selected as a reference standard and be included in all inspections for "G" rating values of that type thereafter, whether represented by a quotation or not. By keeping the same values of "G" components for this fixture, at all times, fixed values for the other fixtures will be accumulated such that these inspections may become unnecessary except where a new fixture is offered, not previously rated. It is recognized, however, that improvements are constantly being made on all fixtures and that these should be considered. A new model of the standard may even be offered, for comparison with the original standard.

Those advising the Purchasing Division with reference to what fixtures are required should bear in mind the suggestion, in the last paragraph in Appendix A on specifications, about use on a period basis.

Appendix D — Application Information

(For the Rating Committee)

1. Applied to Direct Purchase of Fixtures by the Board

While many of the derivations and bases for application are indicated in the text of the Guide, some clarification and, in some instances, additional information is desirable. Virtually all values used in rating fixtures are relative values, not necessarily significant for themselves but accurate in a relative sense.

It will be found desirable to prepare a list of fixture characteristics, such as "Variations" from the "Relative Basic Factor" in RMF_b, relative "Construction" and

*Business Department Employees, Board of School Directors.

"Operating Cost Data," relative "Time for Cleaning" and for "Repairs," etc., for all fixtures as they are rated, for future use. (See Rating Record Card No. 9.)

Rejection of Quotations and Fixtures: See the Specifications accompanying the Request for Quotations, the Specification Section of the Guide and Appendix A, for bases for rejection. No fixture should be rated unless a complete sample and full information are furnished and the fixture itself complies with the specifications. Note particularly all paragraphs under "Sample Fixture" and also the last six paragraphs in Appendix A.

Computation of "F" (relative mean average footcandles delivered in service): These terms are defined as follows. "Relative": no computation of an illumination level is exact, but all computations here are on the same basis and the results are correct relative to each other. "Mean": mean level delivered in service, including application of the maintenance factor. "Average": average level throughout the room.

"CU," the so-called Coefficient of Utilization: This is the proportion of the light developed by the lamps, in a certain fixture installation and in any prescribed room, that will be delivered to the desk plane. As such, this factor appears directly in the "Derivation of Relative Average Footcandles" in the Guide, to determine *F*, which in turn appears inversely in the evaluation of *WEC*. It is therefore imperative that the CU values for the group of fixtures being rated be computed uniformly and accurately. Experience indicates that such values given in the photometric reports can normally be accepted only if they have been computed by the disinterested laboratory itself. For a computation procedure from the photometric *test* data, see the section below on "Computation of CU."

RMF_o: Until other values are recommended, use .82 for 40-watt T12 and 96-inch T12 (430 ma) lamps, and .86 for 40-watt T17 lamps.

RMF_b: Select "Relative Basic Factor" and then alter this after inspecting the fixtures. *Relative*, not specific, values are needed. The values so established should be recorded.

Easily cleaned fixtures will be cleaned more economically, or cleaned more frequently for the same budget. Equate the longest time required for cleaning a fixture to unity, the others in proportion. These figures will also represent the relative periods between cleaning for the same budget and, therefore, the relative proportion of normal soil that will accumulate. Multiply these soil proportions by the loss due to fixture soil (Qualified Basic Factor) and subtract this new soil loss from unity to obtain RMF_b. This process serves to reduce the loss for the easily cleaned fixtures and therefore to increase the footcandle levels they provide.

RMF_c: Explained in Guide.

RMF_d: Loss in light due to room soil is indicated by the difference between CU for a clean and for a soiled room, referred to that for the clean room. For a normal classroom, obtain CU values for 75/50 and 50/30, and assume that the decrease in light will be represented by one-half of this difference.

Computation of CU (Coefficient of Utilization): The computation of CU from the photometric test data seems complex but is easily made as follows:

$$CU \text{ is } \frac{\text{Lumens Delivered}}{\text{Total Lamp Lumens}}$$

There are three components of the Lumens Delivered —

"Hor" component from *L(Hor)*, the lumens emitted in the horizontal zone;

"Ind" component from *L(Ind)*, the lumens emitted in the indirect zone, and

"Dir" component from *L(Dir)*, the lumens emitted in the direct zone.

The sum of these components, divided by the test lamp lumens for the fixture, given near the top of the photometric test report, gives CU.

CU is needed for a typical (E Room Index) room, with 75/50 and also with 50/30 ceiling and wall reflectances. (If CU values are desired for other sizes of rooms or rooms with other reflectances, refer to Tables A-17 and A-18 on pages A-26 and A-27 in the I.E.S. 1952 Lighting Handbook.)

RATING RECORD CARD (#1 of 11)

Bid Date _____

Committee Meeting Date _____

GENERAL INFORMATION

Bidders, with Manufacturer's model offered—Name and Number

1. _____
2. _____
3. _____
4. _____
5. _____
6. _____

	1	2	3	4	5	6
Model No.						
Fixture Name						
Method of Mounting						
Finish of Reflecting Surfaces						
Louver Finish						
Louver Spacing						
Top — Open or Closed						
Number of Lamps Each						
Lamp Type						
F.O.L. Rating						
Photo. Report by E.T.L. or (Name)						
% of Lamp Lumens Emitted 0°-90°						
Emitted 90°-180°						
C.U. — "E" Room 75/50						
C.U. — "E" Room 50/30						
C.U. Computed by						
Test Lamp Lumens						

NOTE: All photometric data must be corrected for same value of test lamp lumens before using.

The relations for these indicated rooms are as follows:

$L(Hor)$ is $10 \times CP$ at 90°

75/50 Hor Component is $.475 \times L(Hor)$

50/30 Hor Component is $.34 \times L(Hor)$

$L(Ind)$ is L (90°-180°) $- .5 \times L(Hor)$

75/50 Ind Component is $.415 \times L(Ind)$

50/30 Ind Component is $.24 \times L(Ind)$

$L(Dir)$ is L (0°-90°) $- .5 \times L(Hor)$

75/50 Dir Component is $M1 \times L(Dir)$

50/30 Dir Component is $M2 \times L(Dir)$

$M1$ and $M2$ are multiplying factors depending in part on the nature of the direct distribution from the fixture, from that of Broad Beam to that of Focusing Beam, according to the following table.

If Flux Ratio $L(0°\text{-}40°) - .65 \times CP$ at 90° / $L(0°\text{-}90°) - 5.0 \times CP$ at 90° is	Beam is
35 - 40%	B — Broad
40 - 45	M — Medium
45 - 50	N — Narrow
50 - 55	VN — Very Narrow
55 - 60	C — Concentrating
more than 60	F — Focusing

RATING RECORD CARD (#2 of 11)

COMPUTATION OF CU — LUMENS DELIVERED OVER LAMP LUMENS (See Appendix D)

	1	2	3	4	5	6
Candle Power at 90°						
L (Hor) 10 × CP at 90°						
Hor. Comp. 75/50 .475 × L (Hor)						
Hor. Comp. 50/30 .34 × L (Hor)						
Lumens (90°-180°)						
L (Ind) L (90-180) − .5 L (Hor)						
Ind. Comp. 75/50 .415 × L (Ind)						
Ind. Comp. 50/30 .24 × L (Ind)						

For Dir. Comp., Flux Ratio is $\dfrac{L(0\text{-}40) - .65 \times CP \text{ at } 90}{L(0\text{-}90) - 5. \times CP \text{ at } 90}$

Lumens (0°-40°)						
.65 × CP at 90°						
L (0-40) − .65 × CP 90°						
Lumens (0°-90°)						
5. × CP at 90°						
L (0-90) − 5. × CP 90°						
Flux Ratio						
Beam (see App. D)						
M1 — Mult. Factor 75/50 (see App. D)						
M2 — Mult. Factor 50/30 (see App. D)						
L (Dir) L (0-90) − .5 L (Hor)						
Dir. Comp. 75/50 M1 × L (Dir)						
Dir. Comp. 50/30 M2 × L (Dir)						
L delivered 75/50 H + I + D Comp. 75/50						
L delivered 50/30 H + I + D Comp. 50/30						
Lamp Lumens (Test)						
CU 75/50 L del/Lp L (75/50)						
CU 50/30 L del/Lp L (50/30)						

RATING RECORD CARD (#3 of 11)

INSTALLATION DATA AND RELATIVE ILLUMINATION RESULTS

	1	2	3	4	5	6
L is Initial Lamp Lumens to be used						
CU is Coef. Util. for "E" Room, 75 50						

RMF Is Relative Maintenance Factor

$RMF_a \times RMF_b \times RMF_c \times RMF_d$

RMF_a Is Reduced Illumination Due to Average Lamp Depreciation

RMF_a — Mean Lamp Lumens in %						

RMF_b Is Reduced Illumination Due to Soil on Fixture, and Is 1 — (Qualified Basic Factor × Relative Cleaning Period)

Relative Basic Factor						
Change for Air Flow						
Change for Position						
Change for Nature						
Qualified Basic Factor, QBF						
Relative Cleaning Period — RCP						
(QBF) × RCP						
RMF_b						

RMF_c Is Reduced Illumination Due to Fixture Deterioration

Estimated Fixture Deterioration						
RMF_c						

RMF_d Is Reduced Illumination Due to Room Soil

C.U. — 75/50 "E" Room						
C.U. — 50/30 "E" Room						
Estimated Loss — %						
RMF_d						

$RMF_a \times RMF_b \times RMF_c \times RMF_d$

RMF						

Then the $M1$ and $M2$ multiplying factors for the E room are

	B	M	N	Vn	C	F
$M1$ (for 75/50)	.755	.785	.805	.825	.845	.855
$M2$ (for 50/30)	.69	.73	.76	.79	.81	.83

For a tabular form for the computation of CU, see Rating Record Card No. 2 of 11.

Computation of C (Annual Cost of Light): Basic Cost Data (for Milwaukee as of January 1, 1953 and subject to change) have been determined in consultation with the electrical engineer for C1-A1, C1-A2, C1-A3 and C2-C, and with the supervising engineer for C2-B. The rate for electrical energy for C2-A has been estimated from representative bills from the power company. Cost data can be approximate so long as the same basis is used for all fixtures.

Computation of C1 (Annual Cost of Installation): **C1-A1:** The cost of the fixtures installed. This is the unit fixture cost plus the cost of assembling and hanging, multiplied by the number of fixtures. The unit cost is the net price, after discount.

Installation cost is hours required times a basic pay of $2.75 per hour. Time includes delivering the fixture to the room, unpacking and disposing of the packing material, assembling, hanging and connecting to the room wiring. Basic is as follows:

Four-foot fixture, indirect type or louvered general diffusing or louvered direct type, 2¼ man-hours (2 men, 1 hour to prepare, hang and connect; one-quarter man-hour to deliver and dispose of the packing material).

Five-foot fixture, general diffusing or direct, no louvers, for low brightness lamps, 1¾ man-hours total.

Eight-foot fixture, indirect or general diffusing type, 3¼ man-hours total.

No difference has been recognized whether fixtures are standing free or are in a row, because of method of lifting into position and extra hangers *vs* inter-connection of fixtures and wiring. Neither has any difference been recognized whether scaffolding or step ladders are used, the former being more rapid and convenient once installed.

Further consideration must be given to recessed fixtures, when used. In this connection, note also G1-A4.

RATING RECORD CARD (#4 of 11)

A — Floor Area of Room

	1	2	3	4	5	6
Room Dimensions						
Area						

Assumed Installation Arrangement

Number of Rows						
N—Number of Fixtures						

DF — Qualifying Factor for Distribution

Flux Ratio from Record Card #2						
1/(2 × Flux Ratio)						
DF Same as Above But Not over Unity						

F — Relative Footcandles — (N × L × CU × RMF × DF)/A

F — Relative Footcandles						

Relative Cost of Light
C is (C1 + C2) — Is Relative Annual Cost of Light

C1 is (C1-A)/Y is Relative Amortized Cost of Lighting Installation

C1-A is C1-A1 + C1-A2 + C1-A3 + or — C1-A4 (See Appendix D)

C1-A1 — Cost of Fixtures Installed

Net Fixture Price, Each						
Expense, Delivered, Unpacked, Assembled, Hung, Connected, Ea.						
Net Cost Each Fixture Installed						
Number of Fixtures						
C1-A1 Total Net Installation Cost						

RATING RECORD CARD (#5 of 11)

C1-A2 — Cost of Wiring, Cabinet to Room Ceiling Outlets and Switches

	1	2	3	4	5	6
Number of Ceiling Outlets						
Cost Each						
Total Cost of Ceiling Outlets						
Number of Switch Outlets						
Cost Each						
Total Cost of Switch Outlets						
Number of 15-amp. Circuits to Room						
Cost Each						
Total Cost of Wiring from Cabinet						
C1-A2 — Room Wiring Cost						

C1-A3 — Cost of Wiring to and including Cabinet, for Room

Total Lighting Watts in Room						
Cost per 100 Watts (See Appendix D)						
Q1-A3 Wiring to Cabinet for Room						

C1-A4 — Incidental Costs

Estimated Cost C1-A4	(Plus or Minus					

C1-A is Cost of Installation, and is
C1-A1 + C1-A2 + C1-A3 + or — C1-A4

C1-A						

C1 — Relative Amortized Installation Cost

Y — 10 Years Nominal Life	10	10	10	10	10	10
C1 is (C1-A)/Y						

This cost of installing can be added to the unit cost of the fixture and then the total multiplied by N, or the installation cost can be multiplied by N and then added to the total price of fixtures for the room.

C1-A2: Cost of room wiring from cabinet, conduit assumed. Allow $15.00 (for time plus material) per 15-ampere circuit to room, however, not less than one circuit per row of fixtures if as much as 600 or 700 watts; plus $15.00 per wired ceiling outlet; plus $10.00 per switch outlet; including switch and plate.

C1-A3: Cost of the building wiring to and including the distribution cabinet, on the basis of $2.00 for each 100 watts lighting load in room (based on $36.00 per room in a 12-room building, providing one 15-ampere, 120-volt load in each room).

C1-A4: The cost of required structural and other incidental work on room surfaces should be estimated for each case and applied as a cost for N fixtures.

C1: The above parts of C1-A are accumulated and then divided by Y, the nominal life of the installation (10 years) to obtain C1, the annual cost of ownership of the installation.

Where necessary, computations can be made for the different sizes of rooms; normally, those for a typical room may be used for all.

Computation of C2 (Annual Cost of Operation):

C2-A: Annual cost of electrical energy. Compute as in Guide, 1000 hours times the kilowatt connected load (including ballasts). Use 2.5c per kw. hr. for usual small buildings. 2c can be used for large buildings.

C2-B: This is a lamp and starter replacement cost and includes the net cost of the lamps and starters, plus expense for labor for replacement. The lamp cost is the net price paid by the Board under its annual contract (or use two-thirds of list) or, where the fixture quotations are given with and without lamps, it is the difference between these quotations, per lamp. The basic labor cost for replacing lamps and starters is $2.00 per hour. This labor includes taking the lamp, starter and stepladder to the room, replacing the lamp and starter (if the latter is to be replaced), dusting the fixture and restoring the ladder. Time allowed is as follows:

Open fixture (no louvers), 10 minutes per lamp (33c).

Four-foot or five-foot fixture, closed with louvers or with glass or plastic part, 12 minutes per lamp (40c).

Eight-foot fixture, closed with louvers or with glass or plastic part, two men 12 minutes per lamp (80c). If 8-foot louver assembly is hinged at one end, one man 12 minutes (40c).

Eight-foot fixture, for four-foot lamps and with four-foot louvers, etc., same as four-foot fixture.

Consider fixtures which permit easy re-lamping from above, without moving louver or other closure, as open fixtures.

No difference ascribed to 8-ft vs 4 ft lamps as such.

Since ordinary starters are to be replaced for each lamp replacement, and non-flicker starters (costing about three times as much) for each third lamp replacement, add 20c in either case for each lamp replacement to approximate this extra expense, charging no additional labor.

C2-C: The cost of repairs depends on the different accessories used and on the accessibility of the various replaceable parts. Twenty-five cents per fixture per year has been estimated for all-metal fixtures with louvers and average accessibility, and 50c for those fixtures with rather freely supported and unframed plastic sides, because of the fragility of these parts. Between these, the following values have been used: for plastic sides, well bound, 30c; for plastic sides, partly bound, 40c.

Rating Factors "G" and "Q" (General and Quality Characteristics):

"G" (General Characteristics): The various values in G are based on relative merits as observed by the rating committee, a penalty first being established in each detail for the poorest fixture in that detail and values for the other fixtures being related to this. As noted under Rating Check Lists in the Guide, the rating procedure considers only fixture "plus" values in each of the details. The General Specifications accompanying the Request for Quotations must be depended on to eliminate any entirely unsatisfactory fixtures.

"Q" (Lighting Quality Characteristics): Brightness values at various angles are given in most photometric reports in "candle/sq. in." values. These must be multiplied

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RATING RECORD CARD (#6 of 11)

C2 is (C2-A + C2-B + C2-C) is Relative Annual Cost of Operation (Appendix D)

C2-A — Annual Cost of Electrical Energy

	1	2	3	4	5	6
Number of Fixtures						
Total Watts Each Including Ballast						
Kilowatts — Total						
Kilowatt-Hours Kw. × 1000 Hrs.						
Rate for Energy						
C2-A — Annual Energy Cost						

C2-B — Annual Cost of Lamp Replacements

Number of Lamps in Room						
Rated Life Each						
Number Replacements (1000 × N)/Life						
Net Price of Lamp, Each						
Allowance, Starter Cost per Lamp						
Labor Cost Each Lamp Replacement						
Total Cost Each Lamp Replacement						
C2-B — Total Cost × Number Replacements						

C2-C — Annual Cost of Repairs

Unit Cost						
C2-C						

C2 — Relative Annual Cost of Operation
C2-A + C2-B + C2-C

C2						

C — Relative Annual Cost of Light
C1 + C2

C						

RATING RECORD CARD (#7 of 11)

COMPUTATION OF "G" RATING — GENERAL CHARACTERISTICS

G is (G1 + G2)/Bogey, 10,000 points

(See Guide for Details)

See Appendix D for reduced bogies where fixtures are included in a general construction proposal

G1 — FIXTURE CONSTRUCTION — Bogey 5500 points

G1 is G1-A + G1-B + G1-C + G1-D + G1-E

G1-A for Mechanical and Electrical Safety — Bogey 2000 points

Penalties

	Cross-Ref.	1	2	3	4	5	6
G1-A1	c1a						
A2	d2a						
A3	f3a						
A4	c4a						
A5	g5a						
A6	5b						
A7	g6a						
A8	e7a						
A9	5c						
A10	5d						
Sum from Bogey G1-A							

G1-B for Mechanical Installation — Bogey 1000 points

Penalties

G1-B1*	7b						
B2*	7c						
B3*	4b						
B4*	7d						
B5*	c8a						
B6*	8b						
B7	7e						
Sum from Bogey G1-B							

*Omit for general construction bid.

RATING RECORD CARD (#8 of 11)

G1-C for Accessories, Fixture Wiring and Electrical Installation

Bogey 700 points

Penalties

	Cross-Ref.	1	2	3	4	5	6
G1-C1	b9a						
C2*	9b						
C3	6b						
C4	6c						
C5	6d						
C6*	8c						
Sum from Bogey G1-C							

*Omit for general construction bid.

G1-D for Replacement of Parts from "Nuisance" Rather than "Economy" Standpoint — Bogey 600 points

Penalties

G1-D1	6e						
D2	6f						
D3	6g						
D4	5e						
Sum from Bogey G1-D							

G1-E for Cleaning from "Nuisance" Rather than "Economy" Standpoint — Bogey 1200 points

Penalties

G1-E1	3b						
E2	3c						
E3	3d						
E4	4c						
E5	c10a 1b, 2b						
E6	5f						
Sum from Bogey G1-E							

G1 is G1-A + G1-B + G1-C + G1-D + G1-E

G1							

CROSS-REFERENCES FOR G1 AND G2

1 (a to e)	Glass G1-A1, G1-E5, G2-C6
2 (a to d)	Plastic G1-A2, G1-E5, G2-C4, G2-C5
3 (a to f)	Louvers, "finish" under 10 G1-A3, G1-E1, G1-E2, G1-E3, G2-C2, G2-C3
4 (a to e)	Detachable Parts other than Louvers G1-A4, G1-B3, G1-E4
5 (a to g)	General Characteristics G1-A5, G1-A6, G1-A9, G1-A10, G1-D4, G1-E6, G2-C8
6 (a to g)	Accessories, Parts and Accessibility G1-A7, G1-C3, G1-C4, G1-C5, G1-D1, G1-D2, G1-D3
7 (a to e)	Hangers G1-A8, G1-B1, G1-B2, G1-B4, G1-B7
8 (a to e)	General Installation G1-B5, G1-B6, G1-C6
9 (a to b)	Fixture Wiring G1-C1, G1-C2
10 (a to e)	Finish, Reflecting and Other Surfaces G1-E5, G2-C7, G2-C8
11 (a)	Reflectors, "finish" under 10 G2-C1

by 452 to obtain footlamberts for the Guide Computations. Where the maximum values needed are not obtainable directly from the data submitted, either the fixture must be rejected or the values estimated from what is given. Any doubt in such a case should be resolved against the fixture. It should particularly be noted that, where the test lamp lumens are not the same in the photometric reports for the several fixtures being rated, proportional corrections must be made in all cases to one common test lamp value.

While brightness data, when carefully obtained, provide a good criterion for comparing fixtures, laboratory technique has not been developed to the point that these values may be accepted as precise.

2. Applied to the Incidental Purchase of Fixtures as Part of a Complete Contract

C1-A1: Fixtures may be included in the total quotation for a construction or installation contract, in which case the proposal should include a base bid plus alternate amounts for various general lighting fixtures, as specified. No firm commitment is made, however, on the fixture cost alone to the purchaser.

In this case, it is necessary that the bidder be required to furnish, with other material accompanying his quotation, a copy of the manufacturer's published price schedule with discounts to consumers. These net prices, for the quantity required, will be used in computing the normal cost of the fixtures installed, C1-A1.

Should the pricing policy of the manufacturer not include the above published schedules and discounts, a statement by the manufacturer giving the net prices he

RATING RECORD CARD (#9 of 11)

G2 — Appearance — Bogey 4500 points
G2 is G2-A + G2-B + G2-C

G2-A for Suitability for Architectural and Use Character of Room and Building where to be Installed — Bogey 2000 poinst

	1	2	3	4	5	6
G2-A						

G2-B for Relation to Other Fixtures for Similar Lighting in Rest of Building — Bogey 1000 points

G2-B						

G2-C for Permanence of Shape and Appearance
Bogey 1500 points
Penalties

	Cross-Ref.	1	2	3	4	5	6
G2-C1	a11a						
C2	3e						
C3	3f						
C4	2c						
C5	2d						
C6	1c						
C7	10b						
C8	5g 10c						
Sum from Bogey G2-C							

G2 is G2-A + G2-B + G2-C

G2							

$$G \text{ is } \frac{G1 + G2}{10{,}000}$$

G1 + G2							
G							

Additional Observations

Prob. Rel. Deterioration of Fixture Surf. (for RMF_s)							
Prob. Rel. Time for Cleaning (for RMF_t)							

RATING RECORD CARD (#10 of 11)

Computation of "Q" Rating — Lighting Quality
Q is (Q1 + Q2 + Q3)/ Bogey, 10,000 points
(See Guide for Details)

Q1 — Maximum Fixture Brightness as Seen — Bogey 6000 points
Q1 is Q1-A + Q1-B

Q1-A for Maximum Fixture Brightness 0°-30°, Bogey 4000 points

	1	2	3	4	5	6
Maximum Brightness Lengthwise of Room						
Q1-A1						
Maximum Brightness Crosswise of Room						
Q1-A2						
Q1-A is Q1-A1 + Q1-A2						

Q1-B for Maximum Fixture Brightness 30°-45°, Bogey 2000 points

Maximum Brightness Lengthwise of Room						
Q1-B1						
Maximum Brightness Crosswise of Room						
Q1-B2						
Q1-B is Q1-B1 + Q1-B2						

Q1 is Q1-A + B1-B

Q1						

Q2 — Maximum Fixture Brightness 45°-90°, Bogey 2000 points

Maximum Brightness						
Q2						

Q3 — Qualified Maximum Ceiling Brightness, Bogey 2000 points

Maximum Brightness of Ceiling						
Q3						

RATING RECORD CARD (#11 of 11)

Q is (Q1 + Q2 + Q3)/10000

	1	2	3	4	5	6
Q1 + Q2 + Q3						
Q						

Computation of "R" Fixture Rating
R is G × Q

R (G × Q)						

Computation of "WRC" — Weighted Relative Cost
WRC is C/F over R

C						
F						
C/F						
R						
WRC — $\frac{C/F}{R}$						

would recommend for the quantities involved will be considered by the Rating Committee, in addition to other information available to it, including previous purchase prices.

Fortunately relative values only are required throughout — based on similar computations for all fixtures. On this basis, the procedure is comparable for all bids.

"G" (General Characteristics): Installation characteristics of the fixture become primarily a responsibility of the contractor, affecting school expense only in connection with alterations and repairs. It is therefore desirable to eliminate certain installation characteristics, such as *G1-B*1, 2, 3, 4, 5, and 6, reducing the Bogey for *G1-B* to 200; and *G1-C*2 and 6, reducing the Bogey for *G1-C* to 500. The total Bogey for *G*1 would then become 4500 and that for "G" 9000. The "G" rating then becomes the sum of the net totals of *G*1 and *G*2 divided by 9000.

Consideration of Entire Contract Proposal: In this case, as for a direct purchase of fixtures, *WRC* values indicate the preferred fixtures. The lowest total quotation including these preferred fixtures, other considerations equal, would be recommended to receive the award. Where several fixtures are being rated within a contract, a weighted average of the *WRC* values would be used.

Appendix E — Abbreviated Report on Ratings

It is recommended that an Abbreviated Report on Ratings be prepared for committee use and to accompany the recommendation for purchase to the Committee on Buildings. This report would include the information indicated below, on six pages. Information for this report would be taken from the Quotations and the Rating Record Cards. Each page would also be headed by "Abbreviated Report" and bid date and committee meeting date.

Summary of Results (#1 of 6)
Code Identification

Column Headings:

Code	Manufacturer	Fixture Name	Model Number
No. & Type of Lamps	% Lumens Up	% Lumens Down	Bidder

8 Columns

Summary of Results (#2 of 6)
Final Results

Column Headings:

Fixtures Rated — Weighted Relative Cost — WRC

Code	Bid-Price	Discount	Net-Price
Relative FC "F"	Relative Cost "C"	C/F	General Rating—G
Quality Rating—Q	Total Rating—R	WRC (C/F)/R	

Fixtures Bid But Not Rated

Code	Bid-Price	Discount	Net-Price	Reasons for Rejection

11 Columns

Summary of Results (#3 of 6)
Relative Illumination Results

Column Headings:

Code	Initial Lp. Lumens	CU "E" 75-50	RMF_a	RMF_b
RMF_c	RMF_d	RMF	A	N	DF	F

12 Columns

Summary of Results (#4 of 6)
Relative Lighting Cost Information

Column Headings:

Annual Cost of Installation

Code	Fixture Price Each	Installed Price Each	Number of Fixtures	Fixtures Installed C1-A1

Annual Cost of Installation

Room Wiring C1-A2	Service Wiring C1-A3	Incidental Cost C1-A4	Annual Install. Cost C1

Annual Operating Cost

Elec. Energy C2-A	Lamp Repl. C2-B	Main. Cost C2-C	Annual Oper. Cost C2	Annual Rel. Cost of Light C

14 Columns

Summary of Results (#5 of 6)
General Characteristic Ratings

Column Headings:

	Construction Rating					Appearance Rating				
Code	Safety Rating G1-A	Instal. Rating G1-B	Elec. Rating G1-C	Replacement Rating G1-D	Cleaning Rating G1-E	Total Construction G1	Arch. Rating G2-A	Bldg. Rating G2-B	Perm. Rating G2-C	Total Appear. G2	General Characteristic Rating G

12 Columns

Summary of Results (#6 of 6)
Lighting Quality Ratings

Column Headings:

	Fixture Brightness 0°-30°		Fixture Brightness 30°-45°			Fixture		Ceiling Brightness	Lighting Quality
Code	Q1-A1	Q1-A2	Q1-A	Q1-B1	Q1-B2	Q1-B	0°-45° Q1	45°-90° Q2	Q3	Q

11 Columns

Appendix F — Definitions of Terms

ASPSL — The American Standard Practice for School Lighting, A.S.A. 23.1, 1948.

Coefficient of Utilization — CU — The proportion of lamp lumens which is delivered in any room, of specific size and surface reflectances, from an installation of specific fixtures, to the working plane in that room. (See Appendix D.)

Electrical Testing Laboratory — ETL — a commercial laboratory in New York City widely used for photometric tests and reports. (Others may be available elsewhere.)

Fixture Classification — Direct, Semi-Direct, General Diffusing, Semi-Indirect and Indirect, depending on proportional light output in the upper and lower hemispheres.

Flux Ratio — the ratio of lumens emitted in the 0°-40° zone to those in the 0°-90° zone, used in describing fixtures by width of "beam" in lower hemisphere. (Appendix D.)

Footcandle — the unit of level of illumination — one lumen of light flux delivered over one square foot of surface.

Footlambert — the unit of brightness level, equivalent to one footcandle reflected from a diffuse surface having 100% reflectance.

Lumen — unit of light flux emitted from a lamp, etc. — as also used here, delivered in an angular zone or on a surface.

Maintenance Factor — mean illumination level maintained in service in per cent of initial level, new and clean.

Photometric Report — a report on a photometric test, showing the candlepower distribution at various angles (usually normal to, parallel to, and at 45° to the axis of the lamp); also the lumens in 10° zones and for 0°-40°, 0°-90°, 90°-180° and 0°-180°, actual and in per cent of lamp lumens; also the maximum brightness of the fixture and lamp at various angles normal (crosswise) to and in the axis (lengthwise) of the lamps. In the above brightness data, 0° is horizontal, in the distribution curve 0° is directly down from the fixture. When any accumulated lumens for a large angular zone are needed and are not given, they are easily added in the table for 10° zones.

Room Reflectances — the reflecting capacity of the wall and ceiling, usually expressed in fractional form. Thus a 75 per cent ceiling and a 50 per cent wall is described in the Guide as 75/50.

Shielding Angle — the angle down from horizontal at which any part of the lamp is first visible. Usually noted as "crosswise" and "lengthwise."

Underwriters' Labortories, Inc. — a laboratory inspection service assuring maximum safety and security of devices and parts, indicated by the UL label. Widely used by lighting equipment manufacturers.

Conference Paper Discussors, Note

Written discussion on any of the technical papers from the I.E.S. 1953 National Technical Conference should be submitted immediately for publication in Illuminating Engineering.

Send: One copy (original) to Miss Ruby Redford, Editor, Illuminating Engineering, 1860 Broadway, New York 23, N. Y.

One copy to L. E. Barbrow, Co-Chairman, Papers Committee, at the National Bureau of Standards, U. S. Department of Commerce, Washington 25, D. C.

One copy to author of paper.

TELECAST

LIGHTING NEWS OF CURRENT INTEREST

Winners Selected in Finals, My Most Interesting Job Contest

EIGHT entrants in the M.M.I.J. Contest with L. E. Taylor, Chairman of the Lighting Service Forum, standing at left, are: seated, Merrill R. Humber, Benoit C. Doucet, Walter Toly who was proxy for Don E. Frank; standing, R. R. Duncan, Jr., M. G. Zervigon, Nick Stuffer, Henry Koether, and L. E. Spears; not shown: E. J. Whitlow.

The National Technical Conference ended too late to make the deadline for this issue — but news too hot to hold is the long-awaited outcome of the Contest for "My Most Interesting Lighting Job." This was held Tuesday afternoon, September 15, and featured nine Regional Winners of previous contests.

The race was so close that a tie was awarded to fourth place — making five winners in this year's competition. Details, with pictures of the five winning installations will be a feature of the November issue of I.E.; the four runners up will appear in December.

Winners were:

First Prize — $100.00

MERRILL R. HUMBER, Humber & Walker Co., San Francisco, California. "Lighting the Broadway Tunnel."

Mr. Humber's entry won first place in the contest conducted by Northern California Section, and again first place at the South Pacific Coast Regional Conference.

Photos courtesy Bob Blatt, *Electrical World*

JUDGES pondering their decisions in the close contest are l. to r. around table: President E. M. Strong; Lester Graves, W. H. Little, S. G. Hibben and C. L. Crouch.

CERTIFICATE for first place is presented to Merrill R. Humber by Professor Strong.

Report on the National Technical Conference To Be in November I. E.

The complete report on the National Technical Conference, with photographs of the major events, awards, and other highlights of the New York meeting, will be featured in the Telecast Section of the November issue of I. E.

Second Prize — $50.00

NICK STUFFER, Westinghouse Electric Corp., Cleveland, Ohio.

This entry covering an ingenious solution to a lighting problem in an executive's office, represented the Great Lakes Region. Mr. Stuffer had previously won for the Cleveland Section of I.E.S.

Third Prize — $25.00

MARIO G. ZERVIGON, Louis N. Goodman and Associates, New Orleans, La.

The Southern Region's entry was an extremely interesting application of floodlighting for a modern building of cellular design.

Fourth Prize — $15.00 — A tie for this place went to:

HENRY KOETHER, Wisconsin Electric Power Co., Milwaukee, Wis. "Lighting the Grand Store." Mr. Koether represented the Midwest Region.

L. E. SPEARS, Pennsylvania Power Co., New Castle, Pa. "Lighting Perlman's Jewelry Store." This entry was the East Central Region's winner.

Runners up at the National Contest were:

BENOIT C. DOUCET, Curtis Lighting, Inc., Montreal. "Re-Lighting St. Ensebe Church." This job previously took first place for the Montreal Section and the Canadian Region.

E. J. WHITLOW, McClure Electric Co., Dallas, Texas. "Lighting a Television Broadcasting Tower." The entry was first place winner in Southwestern Region's contest. (Mr. Whitlow's entry was presented in his absence by M. J. Myers.)

DON E. FRANK, Columbia Electric & Manufacturing Co., Spokane, Wash. "Re-lighting a Bank Lobby." Mr. Frank's entry, presented in his absence by Walter Toly, represented the Pacific Northwest Region.

R. R. DUNCAN, JR., New Bedford Gas and Edison Light Co., New Bedford, Mass. "Harvard Trust Company Director's Room." This job was winner for the New England Section and Northeastern Region.

Judges at the National contest were acknowledged leaders in illumination. These were: Prof. E. M. Strong, Cornell University, Ithaca, N. Y.; C. L. Crouch, Technical Director of I.E.S.; S. G. Hibben, Westinghouse Electric Corp., Bloomfield, N. J.; W. F. Little, Electrical Testing Laboratories Inc.; Lester H. Graves (retired), Past-President of I.E.S.

Study Clubs Forming in Amarillo and Lubbock, Texas

Organizational meetings are being held for the formation of study clubs in Amarillo and in Lubbock, Texas, as reported by M. J. Myers, incoming Regional Vice-President of the Southwestern Region. Enthusiastic I.E.S. members in the two cities have planned formal meetings for October and are already looking ahead to the formation of Chapters. In Amarillo the guiding spirits are T. J. Lynn and T. G. Hart, both with Southwestern Public Service Co.; in Lubbock Lee Collins of General Electric Supply and Nolan Swain of Southwestern Public Service are steering the activity.

College Professors Attend Industry Seminar

A week-long seminar at the Westinghouse Educational Center, Pittsburgh, Pa., climaxed an industrial experience program for college professors and instructors who have been working since early summer at the company's plants.

Eighteen faculty men, participants in the company's sixth annual Industrial Experience Program were joined by 18 other professors from leading engineering colleges for the seminar. The theme of the seminar, "Recognizing our Responsibilities," was highlighted by an interchange of problems common to both industry and university. In addition, top officials of Westinghouse discussed training of engineers for industry and management development. Tours were also made of the East Pittsburgh and Sharon plants.

Under the Industrial Experience Program, 18 professors and instructors from colleges as far north as Massachusetts and as far west as Nebraska have been working during the summer side-by-side with engineers and specialists of Westinghouse in order to pass on first-hand information about industry to their students when they return to the campus this autumn.

I.E.S. Mid-South Chapter Publishes a "Newspaper"

"The Mid-South News" is the latest of the bulletins published by I.E.S. Sections and Chapters to keep their members informed on local activities. News on the Chapter's committee appointments, a message from the incoming Chairman, membership information and reminders on events planned for the Fall season are some of the news items in a recent issue.

Emblem Chosen for Light's Diamond Jubilee

The Light's Diamond Jubilee Committee has adopted an emblem for the 1954 celebration of the 75th anniversary of Edison's invention of the first practical incandescent lamp. The face of the emblem shows Edison's first incandescent lamp bulb held against the atomic symbol. This representation symbolizes both past and future practical applications of electricity, the theme of the Jubilee celebration.

The reverse of the emblem gives the Jubilee slogan, "Light for Freedom — Power for Progress," epitomizing the role of electricity today. The text, "Commemorating Thomas A. Edison's invention of the first practical incandescent

lamp, October 21, 1879," and a laurel branch complete the design.

The Jubilee Committee, which is composed of representatives from all segments of the electrical industry, will coordinate the industry-wide activities of the celebration.

Rocky Mountain Electrical League Holds 50th Annual Convention

Leaders of all fields of the electric industry in the mountain states met at the Broadmoor Hotel, Colorado Springs, Colo., September 20-23 for the 50th Annual Convention of the Rocky Mountain Electrical League.

More than 400 dealers, distributors, manufacturers, contractors, and utility men from Colorado, Wyoming and New Mexico, and the southwest area of South Dakota attended the convention. The meeting was designed to illuminate both national and local attainments, and expectations for the future.

In addition to presentations by fourteen speakers, nationally known in their fields, league members commemorated a half-century of organized electrical progress.

Identification Emblem For CBM Ballasts

A diamond-shaped emblem, reading "CBM Certified by ETL," has been adopted by the Certified Ballast Manufacturers to identify the ballasts of the member companies. The emblem will be carried on printed labels and stamped into the ballast case.

I.E.S. Regional Conferences, 1954

Southern	Roosevelt Hotel New Orleans	April 8-9
Southwestern	Rice Hotel Houston	April 11-13
Inter-Mountain	Denver	April 15-16
South Pacific Coast	Museum of Art San Francisco	April 19-20
Pacific Northwest	Benjamin Franklin Hotel Seattle	April 22-23
Canadian	King Edward Hotel Toronto	April 28-30
Great Lakes	Sheraton-Cadillac Hotel Detroit	May 3-4
Midwestern	Jefferson Hotel St. Louis	June 17-19

School Lighting Guide Prepared by New Orleans Section

The Advisory Committee on School Lighting of the New Orleans Section, I.E.S., with S. C. Berdon, Chairman, has prepared a General Guide for Better School Lighting and has presented it to the Office of Planning and Construction of the Orleans Parish School Board. This outline, made at the request of the School Board, covers four interdependent sections: Guidance in the Design of Lighting Systems; Selection of Luminaires and a Rating System; Maintenance, and Education. Standardization of lighting equipment and simplification of maintenance are considered along with the primary goal of adequate lighting for the seeing task.

From the ASA Newsletter

The following excerpts are taken from the sixth issue of the ASA Newsletter (September) distributed by the American Standards Association.

National Electrical Code (C1-1953) has been approved in a new triennial revision. Adopted as an American Standard in 1919, the Code is the basic standard that controls electric wiring in most of the nation's buildings. Municipalities use it in legal enactments, and insurance companies as advice to their insured. The Electrical Code Committee, sponsored by the National Fire Protection Assn., under the leadership of Merwin Brandon of Underwriters' Laboratories, makes recommendations and interim revisions which are reviewed when the Code is revised every three years.

Revisions in four American Standards for transformers, regulators and reactors are the published result of eleven years of work by Committee C57.

Three new projects were authorized by the Council meetings of the International Organization for Standardization in Geneva. Technical Committee 78 will undertake standardization of aerometric hydrocarbons. Committee 79 will work on light metals and their alloys. Committee 80 will work on safety colors. Secretariats of the committees will be furnished by I.S.O. member bodies from United Kingdom, France and the Netherlands, respectively.

Charles Le Maistre, a pioneer and veteran of British and international standarization, has died in England. He was director of British Standards Institution (1929-1943), secretary of the United Na-

(Continued on page 11A)

MEXICO CHAPTER, I.E.S. held a dinner meeting July 30 at which the 35 members and guests heard Sabino Escobedo Gameros, lighting engineer with General Electric Co., who spoke on "Visual Comfort in the Design of Interior Illumination." The meeting was held at the Club Americano.

INSTALLATION: Society for Savings, East Hartford, Connecticut. Branch, East Hartford, Connecticut.

ELECTRICAL CONTRACTOR: Gunning Electric Co., Hartford, Conn.

FIXTURES: Litecontrol No. 5924 2 lamp slimline recessed troffers, 4' long, using No. 9015 Holophane Low Brightness Lens.

SPACING: 9'-0" on centers.

CEILING HEIGHT: 9'-6" approximately.

INTENSITY: 50 Footcandles average in service, over work area.

What Time is it?

It's twenty-five to ten by the clock on the back wall there. Easy to read isn't it? Yet it's over 50 feet away. No glare or sharp contrasts to cut down your vision.

LITECONTROL Fixture 5924 and smart planning lift this lighting installation out of the ordinary. There is little exposed brightness because the fixtures are recessed, with Holophane 9015 Low Brightness Lenses.

Crosswise layout of lamps increases apparent width of the bank. Continuous lighting lines concentrate intensity over the work areas. Broken lines furnish all that's needed over the light colored floors.

The entire layout — lighting, painting and simple arrangement of furniture — produces a clear, workable, comfortable room.

NOTE — LITECONTROL Fixture 5924 provides unusual efficiency, simple installation and maintenance.

For more information on this and other LITECONTROL Fixtures write for catalog, today.

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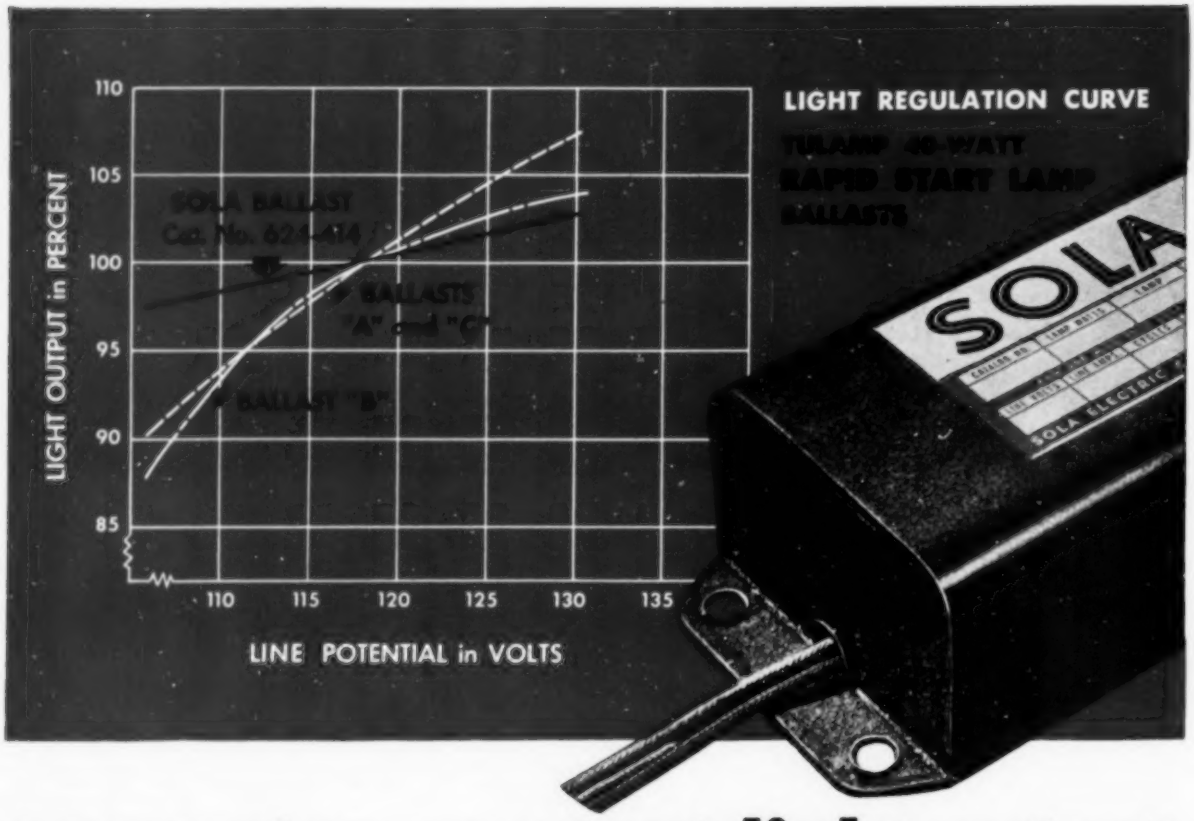

guarantee constant light output

from your rapid start lighting system with SOLA Constant Wattage Ballasts

You design your rapid start lighting system to deliver a specific number of foot candles at a specific working surface. *Your customer* buys your system on the basis of that expected performance . . . but what happens to light output when line voltage varies? With ordinary unregulated ballasts lumen output and efficiency will drop significantly with line voltage . . . with Sola Constant Wattage Ballasts lumen output will be maintained within ±2.5% or less with line voltage variations as great as ±10%.

In addition to maintained light output Sola Constant Wattage Ballasts for rapid start lamps offer many additional advantages: long lamp life, cool operation, self protection against damaging heat rise when lamps fail, absolute safety when relamping, unusually quiet operation, low purchase cost.

You automatically guarantee all the light you proposed when your installation is ballasted with Sola Constant Wattage Ballasts. You guarantee your customer's satisfaction through continuous, dependable performance. Write for full information, or request a Sola sales engineer to call and give you all the illuminating facts.

SOLA *Fluorescent* **BALLASTS**

WRITE FOR RAPID START BALLAST BULLETIN CFL-191

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PHILADELPHIA: Commercial Trust Bldg., Rittenhouse 6-4988 • BOSTON: 272 Centre St., Newton 58, Mass., Bigelow 4-3354
CLEVELAND 15: 1836 Euclid Ave., PRospect 1-6400 • KANSAS CITY 2, MO.: 406 W. 34th St., Jefferson 4382 • Representatives in Principal Cities

(Continued from page 8A)

tions Standards Coordinating Committee (predecessor of the I.S.O.), and general secretary of the International Electrotechnical Commission since its founding in 1904 until his death.

National Standardization Conference is being held at the Waldorf-Astoria, New York, October 19 and 21. The Annual Award Luncheon is being held October 21 when the Howard Coonley Medal and the Standards Medal will be presented.

Three-Day Conference Held at Nela Park Institute

A three-day conference for architects, designers, and engineers was held September 30 - October 2 at the Nela Park Lighting Institute of the General Electric Co. Topics discussed on the program included:

Lighting Offers Architects Opportunities
Development of the Seeing Environment
Scientific Basis for Specifying Lighting
What's Newest in Light Sources
School Lighting Practice — Lighting in Nine-Foot Ceiling Rooms
Office and Drafting Room Lighting
Demonstration of Modern Residential Lighting Techniques
What to Look for in Lamp Value
Decorative Lighting for Interiors
Industrial Lighting — Demonstrations and Examples from the Field
Color Techniques in Industry and Commerce
Lighting for Selling
Bactericidal Lamp Applications and Hospital Lighting
Modern Electrical Distribution Systems

Group conferences were held on specific applications requested by those attending.

Bibliography on Lighting Available from Headquarters Office

A list of books, publications and periodicals, compiled and kept up-to-date by the I.E.S. Committee on Lighting Education, is available from the Technical Department at I.E.S. headquarters office. Consisting of nine mimeographed sheets, this bibliography on light and lighting covers publications which make a definite contribution to the field of illumination, grouped according to the subject matter which they represent.

RETIRING Officers and Committee Members of the Southern California Section at their September 2 meeting (above): F. J. Rohring; Oscar Meissner; Ben Hartmann; Roy Bevan (behind Mr. Hartmann); S. H. Simonsen; D. W. Prideaux; C. E. Mauk; Roy E. Dahlin; Robert Jones; Harry Dobson; R. H. Kreyser; E. E. Coleman; Del Reynolds; Robert Hirte; Ted Shepherd and, seated, Regional V-P Leonard Hobbs. Below right, Past Chairman's Certificate is presented to Roy E. Dahlin, Outgoing Chairman of the Section, by Regional V-P Leonard Hobbs.

These sections are (1) Lamps and Lighting, (2) Architecture and Lighting, (3) Physics of Light—Optics, (4) Color, (5) Light, Eyesight and Health—Related Psycho-Physiological References, (6) Trade Papers and Professional Journals in both English and foreign languages.

IT SEEMS TO ME

Basic Quantities and Concepts In Illuminating Engineering

I should like to make two comments on the article, "Basic Quantities and Concepts Used in Illuminating Engineering," by D. M. Finch, which appeared in the July issue of ILLUMINATING ENGINEERING.

I notice that the author is Chairman of the I.E.S. Committee on Nomenclature and it is therefore rather disturbing to find that he has chosen the symbol *L* for luminous emittance (lumens emitted per unit area by a surface) although this symbol has been adopted internationally to denote luminance (photometric brightness). The C.I.E. resolution of 1948 reads:

> "It is recommended that the symbol *L* be no longer used to denote quantity of light (product of a luminous flux by a time). It shall henceforth be reserved, equally with the symbol *B*, to denote a luminance (photometric brightness)."

In 1951 the C.I.E. definition of luminance included only the symbol *L*, the *B* having been dropped, along with the alternative term, "photometric brightness."

The United States National Committee was a party to these international decisions and it is therefore both surprising and disturbing to read (near the end of the article "It is recommended that the name 'Photometric Brightness,' with symbol *B*, be retained by the I.E.S. as the official designation for the basic brightness quantity having directional

(Continued on page 15A)

I.E.S. National Technical Conferences

September 12-16, 1954 — Chalfonte-Haddon Hall, Atlantic City

September 12-16, 1955 — Statler Hotel, Cleveland

September 16-21, 1956 — Statler Hotel, Boston.

CRIME AFTER DARK, which flourishes on poorly lit streets, spurred the drive for better lighting. The City Council studied the new modernization plans to provide more effective lighting.

CITY ACTS with a new relighting program for its 100,000 citizens. Mississippi Power and Light Company installed new lights on main streets after planning program with the City Council.

JACKSON THROWS LIGHT ON

DARK STREETS before relighting (above) were often hazardous for drivers and pedestrians. Criminals molested the late strollers, damaged or entered parked cars, and broke store windows.

SAFE STREETS after relighting (below) sharply cut traffic injuries, eliminated the traffic fatalities, and helped police reduce crimes. Traffic moved faster and business was increased.

PLEASED CITIZENS of Jackson like the increased safety provided by the new street lighting. Pedestrians no longer fear criminal attacks, and now feel safer walking or shopping at night.

INCREASED BUSINESS is enjoyed by retail merchants such as jeweller J. T. Stallings, who says, "Lighting increases sales, aids our window displays, and draws in new trade from beyond our city."

CRIME AT NIGHT

WINS AAA PEDESTRIAN SAFETY AWARD

Jackson, Mississippi has proof of what good street lighting can do to improve a city. Crimes at night have been virtually eliminated on the relighted streets. The new lighting has helped reduce traffic accidents so that not one fatality or injury occurred on these streets in 1952. Business has prospered with merchants reporting increases up to 20% in sales.

The relighting program for Jackson was inspired by the desire to become the "safest city in the nation." The American Automobile Association awarded Jackson a special citation for its record of no pedestrian injuries or fatalities for cities in the 50,000–100,000 population class in 1951.

According to Chief of Police, W. D. Rayfield: "Crime on the city streets has almost disappeared since relighting. The visibility is so fine, that our men can spot a fly moving three blocks away!" And Fire Chief L. F. McDonald says that his equipment can now move faster and more safely to safeguard life and property. The Mayor of Jackson, Allen C. Thompson said, "Installation of new street lights is one of the most important steps we have ever taken to make the city safe and pleasant for its citizens and those from surrounding areas. It has assisted the police and fire departments in their vital work and is making Jackson look more progressive and more prosperous." The relighting program in Jackson is now continuing through the remainder of the city streets.

PROPERTY IS SAFER since new street lights were installed. Police and Fire Departments can get to the scene faster and work more efficiently.

MAYOR Thompson and Rex Brown, President of Mississippi Power and Light Co., are proud of the AAA recognition of Jackson's traffic safety.

How you can benefit by G-E Lighting Engineering

Everywhere in America, cities large and small are becoming safer, more pleasant places in which to live, with the aid of G-E Lighting Engineering. G.E.'s broad experience can help your electric utility plan and promote better lighting in your community too. With the most complete line of equipment available, G.E.'s Lighting Engineers can provide the finest lighting obtainable for every kind of lighting problem. For new literature, write Section 452-134, General Electric Co., Schenectady 5, New York.

You can put your confidence in—

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PEERLITE with GRATELITE* LOUVER
also available with Glass, Lens Bottom
GUTH
PEERLITE
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Permits flexible pattern planning. You can form any design you wish.
For 2, 3, or 4 lamps—4' or 8' long.
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AIR CONDITIONED!

it's cool inside

more cooling
less cleaning

Wide open on top and bottom
for brisk air-circulation

Cool lamps last longer.
Clean lamps stay brighter.
Clean fixtures give more light!

RESULT: greater efficiency
less maintenance
long-lasting beauty

*U. S. & Can. Pats. Pend.
Trademark registered

Write on your letterhead today for Catalog 911-I.

THE EDWIN F. GUTH COMPANY ST. LOUIS 3, MO.

Leaders in Lighting since 1902

(Continued from page 11A)

properties . . . " Is it too much to hope that the matter will have further consideration?

From quite a different point of view I should like to disagree with the author's treatment of what he calls the "Lambert system" of luminance units. He writes "The footlambert is the unit of luminous emittance equal to one lumen per square foot" and adds "For sources that *do not have uniform photometric brightness* in all directions but for which the actual photometric brightness is known in a particular direction, the *equivalent* luminous emittance is determined for a source having the same actual photometric brightnes sand an assumed cosine distribution of such a magnitude that the *equivalent* luminous emittance is π times the actual photometric brightness." Surely this is an unnecessarily complicated way of looking at the matter. As I have written elsewhere (in 1946) "The unit is a unit of brightness and, as such, it can be used to express any brightness whatsoever; the fact that it was derived from a consideration of the behavior of a perfect diffuser is immaterial. Thus we may say that a surface has a brightness of x footlamberts when viewed in any direction if, in that direction, its brightness is the same as that of a perfect diffuser emitting or reflecting x lumens per square foot."

I do not think there is any justification for regarding the "Lambert units" as units of luminous emittance rather than as units of luminance. The conception of luminous emittance has never found any wide acceptance among photometric workers either in the United States or in Great Britain and I am convinced that the footlambert is generally (and rightly) regarded as an alternative to the candela per unit area. — JOHN W. T. WALSH, *2, Cambridge Crescent, Teddington, England.*

No Odor to Tungsten

Having just completed a preliminary report on "Corrosion in Abbatoirs" and with smells still in my system, I opened the August issue of ILLUMINATING ENGINEERING.

Mr. G. R. Moritz' article on "Tungsten in the Lamp Industry" was a refreshing change and the very apt cartoons were good for numerous chuckles.* I think Mr. Moritz deserves an "Oscar" for reducing the complex to its simplest components. — F. R. JEFFREY, *Crouse-Hinds Co. of Canada, Ltd., Toronto, Ont.*

*The cartoon drawings accompanying Mr. Morits' article were the work of the artists on the staff of the *Westinghouse Engineer*.— EDITOR.

OBITUARIES

Collin H. H. Kilburn, illuminating engineer for many years with the Western Massachusetts Electric Company in Greenfield, Mass, died recently at the age of 51. In World War II Mr. Kilburn served as a major in the Army, but his informal title of "Cap" stayed with him to the time of his sudden death, and was the name by which he was known to his many friends in the New England Section of I.E.S.

Ludvig C. Larson, Professor of Electrical Engineering at the University of Wisconsin and director of the Electrical Standards Laboratory died recently after a long illness at the age of 54. An active member of the Milwaukee Section of the Illuminating Engineering Society since he joined in 1947, Professor Larson was an authority in photometric and illumination testing and measurements.

Otto R. Wollentin, manager of equipment design and development at the Westinghouse Lamp Division in Bloomfield, died August 19 at the plant where he had been employed for nearly 36 years.

BOOKS AND PAMPHLETS

Vision Through the Atmosphere by W. E. Knowles Middleton, published 1952 by University of Toronto Press, Toronto, Canada, 264 6½ x 10 inch pages, 111 illustrations, 26 tables; price $8.50. This volume replaces the author's 1935 and 1941 *Visibility in Meteorology.*

To quote Dr. Middleton: "In the decade which has elapsed since . . . the problem of seeing through the atmosphere has been given intensive and very costly consideration in several quarters, particularly in the United States and in Great Britain. . . . The subject has entirely changed its aspect in the last ten years. For these reasons this book has been written from an entirely new standpoint, emphasizing the physical and psychological bases of the problem. There are no purely climatological or synoptic chapters, such as the last two in the former book."

Topics treated include: elementary photometric theory, extinction of light in the atmosphere, alteration of contrast by the atmosphere, relevant properties of the eye, visual range of objects in natural light, visual range of light sources and of objects illuminated by artificial light, colors of distant objects and the visual range of colored objects, instruments for measuring visual range and related quantities, estimates of visual range, threshold of contrast, threshold of illuminance in meteorological practice. The book terminates with an excellent bibliography of about 420 entries.

Written by an authority in the optics of meteorology *Vision Through Atmosphere* will be of value to engineers dealing with signal lighting, aviation lighting, vehicle headlights of all types, outdoor advertising and highway lighting under adverse weather conditions.

Interflectance in Two Dimensions, by Melchor Centeno V. and Anatole Zagustin. 20 pages, paper bound. Printed in Spanish and English. Universidad Central de Venezuela, Facultad de Ciencias Matematicas y Naturales, Caracas, Venezuela.

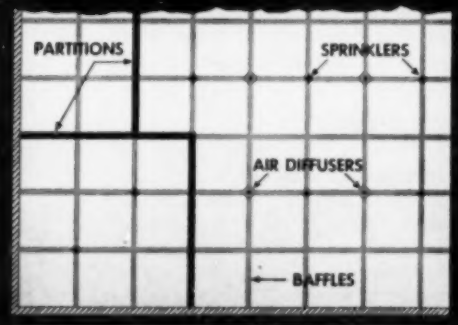
The authors have presented an analytical method of determining the illumination in a cylinder of regular cross section with a point-by-point method which includes interflectances. To do this they have taken the basic formulae for illumination and applied them to the special case in which they were interested.

Thus, the method they have developed can be used to determine the illumination in a tunnel, on a roadway, in a hallway, or on any other long narrow area. It is also well adapted for solving problems that cannot be solved readily using existing methods such as those in which the brightness of a large area source is non-uniform or located at an angle between the walls and the ceiling.

Since the illumination obtained is the illumination at a point, several calculations are necessary in order to obtain the average illumination level. Thus, the method would be similar to the common point-by-point method except that interflections are also comprehended.

(Continued on page 27A)

All essential ceiling components in a single integrated modular system



At each modular interval of Sigma-Plex either an acoustical baffle or a movable partition may be set in place. Sprinklers or supplementary air diffusers may be mounted at the intersections of baffles. Names of reputable manufacturers of movable partitions, high velocity venturas and sprinklers for integration with Sigma-Plex will be furnished by Wakefield.

for combining

- **lighting**
- **acoustics**
- **air diffusion**
- **sprinklers**
- **movable partitions**

that's Sigma-Plex

The architect's plea for functional compatibility of diverse components is answered once and for all by Sigma-Plex. For now the architect may design office areas of any size or shape knowing he has available to him, as standard products, a number of the most important interior elements, all ready for integration into a harmonious whole.

Job-engineered to the modular requirements of the building, Sigma-Plex as supplied by Wakefield consists of:

A Ladder-Type System of lamp holders together with lighting and wiring channels to be mounted directly on the structural ceiling. From these channels, receiving channels are suspended to support the light diffusers and to receive either acoustical baffles or movable partitions.

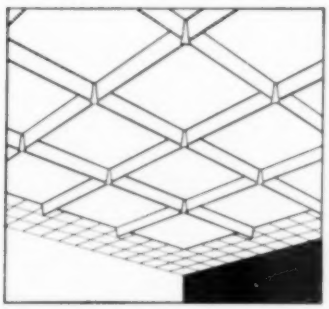
Rigid-Arch Plastic* Diffusers framed in extruded aluminum. These diffusers have a non-specular matt finish, and are arched from edge to edge for extra rigidity. A special Touch-Latch permits lowering and re-closing the panels from the floor by means of a touch rod.

**Plexiglas*

Acoustical Baffles of perforated metal filled with a fiber glass core. These baffles are interchangeable with movable partitions at any modular interval. Sprinklers or supplementary air diffusers may be mounted as desired at baffle intersections. Partitions, sprinklers and venturas are not supplied by Wakefield; see note on left page.

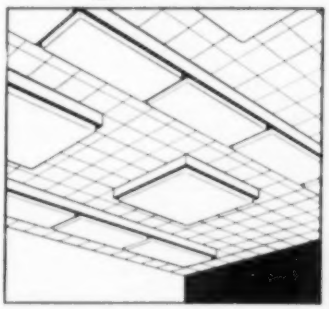
Sigma-Plex is one of a series of Wakefield Geometrics. The others:

Theta-Plex



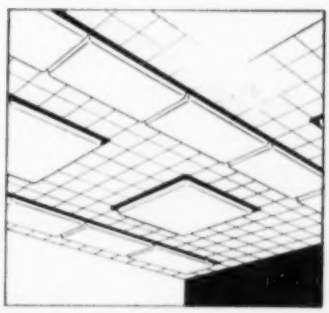
Designed on a four-foot module, Theta-Plex permits coordination of Rigid-Arch plastic diffusers, acoustical baffles, supplementary ceiling areas of acoustical tile, sprinklers and supplementary air diffusers. At each four-foot interval an acoustical baffle may be set in place; or four-foot panels may be joined together in varied combinations.

Omega-Plex



Omega-plex is a complete unit with Rigid-Arch Diffuser, ready for on-surface mounting with no structural ceiling changes required. It comes in four sizes: 4′ x 4′, 2′ x 4′, 2′ x 2′ and 1′ x 4′. Ballasts and lamp holders are contained in an individual metal housing. Omega-Plex may be used individually or combined in a variety of designs. Available with louvers.

Beta-Plex

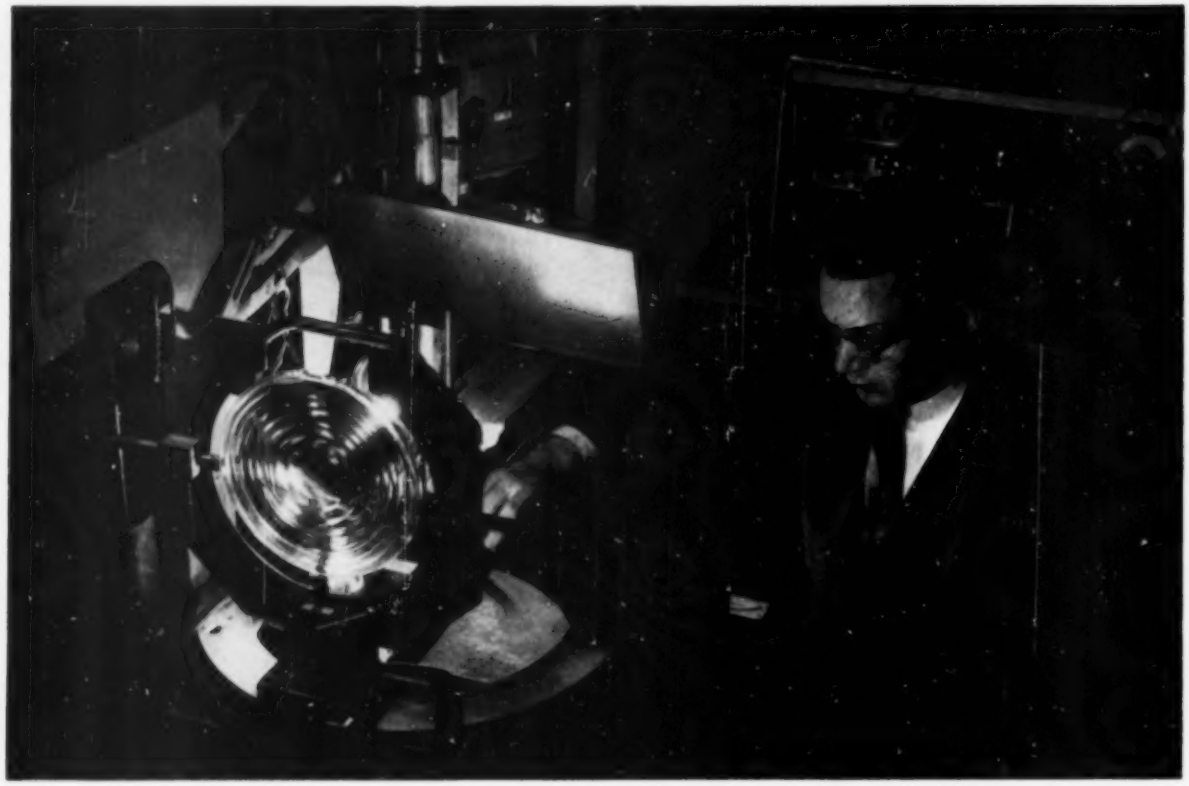


Beta-Plex is a complete unit with Rigid-Arch Diffuser, ready for recess mounting in a suspended ceiling. It comes in 4 sizes: 4′ x 4′, 2′ x 4′, 2′ x 2′ and 1′ x 4′. Ballasts and lamp holders are contained in an individual metal housing. Employing various Beta-Plex sizes, singly or in continuous patterns, the architect can create numerous designs. Available with louvers.

An eight-page, three color folder, with illustrations, technical drawings and descriptive text, has been prepared for each of the Wakefield Geometrics. Copies will be sent you if you will write The F. W. Wakefield Brass Company, Vermilion, Ohio. In Canada, Wakefield Lighting Ltd., London, Ont.

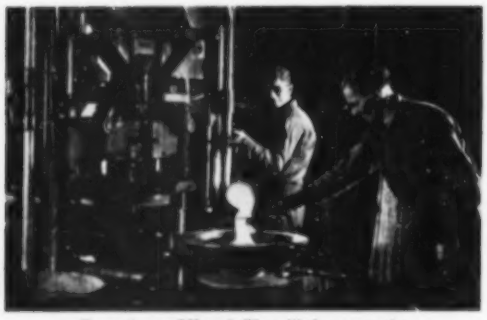
WAKEFIELD GEOMETRICS

Integrated modular components for functional ceilings



TOUGH SPECIFICATIONS

are KOPP's "meat"!



Two views of Kopp's "hand" shop, pressing (above) and blowing (below).

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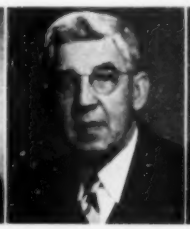

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(*Continued on page 24A*)

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(Continued from page 22A)

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Chairman — H. D. SILER, Pittsburgh Reflector Co., 403 Oliver Bldg., Pittsburgh, Pa.
Secretary — F. B. MAHON, Duquesne Light Co., 435 Sixth Ave., Pittsburgh, Pa.

Puget Sound Section — Pacific Northwest Region

Chairman — R. E. ADAM, 2430 9th Ave. W., Seattle, Wash.
Secretary — D. A. PEARSON, General Electric Company, 202 Hoge Bldg., Seattle, Wash.

Quebec Chapter — Canadian Region

Chairman—OSCAR DORVAL, 1012 Gauthier St., Sillery, P. Q., Canada.
Secretary — GEORGES HOPKINSON, Tri-Bec Inc., Industrial Centre No. 5, Quebec, Que.

Rochester Section — Great Lakes Region

Chairman — P. H. OWEN, Rochester Gas & Electric Corp., 89 East Avenue, Rochester, N. Y.
Secretary — A. R. PRINCIPE, 223 Linden St., Rochester, N. Y.

Rocky Mountain Section — Inter-Mountain Region

Chairman — A. F. WEERS, Weers Electrical Planning Service, 1150 Jackson St., Denver, Colo.
Secretary — C. O. WOODWORTH, Public Service Co. of Colorado, 900 15th St., Denver, Colo.

St. Louis Section — Midwestern Region

Chairman—G. F. HEROLD, Harry F. Wilson Consulting Engineer, 4908 Delmar, St. Louis, Mo.
Secretary — BROOKS CHASSAING, 911 Locust St., St. Louis, Mo.

San Diego Chapter — South Pacific Coast Region

Chairman — C. M. THOMPSON, San Diego Gas & Electric Co., P. O. Box 1831, San Diego, Calif.
Secretary — C. J. BUNCE, Bureau of Home Appliances, Electrical Contractors' Division, 861 Sixth Ave., San Diego, Calif.

San Jacinto Section — Southwestern Region

Chairman — N. O. REED, Day-Brite Lighting Fixtures, 1602 W. Main, Houston, Texas.
Secretary — G. A. PEABODY, Peabody Brothers, 866 M & M Bldg., Houston, Texas.

San Jose Chapter — South Pacific Coast Region

Chairman — W. E. NORDBY, 85 Lincoln Drive, Santa Clara, Calif.
Secretary — HARRY OWEN, 133 Locust St., San Jose, Calif.

Southeast Florida Chapter — Southern Region

Chairman — R. L. O'DONOVAN, O'Donovan Electric Co., 212 N. W. 8th Avenue, Miami, Fla.
Secretary — R. J. BRADLEY, Florida Power & Light Co., 25 S. E. 2nd Avenue, Miami, Fla.

(Continued on page 27A)

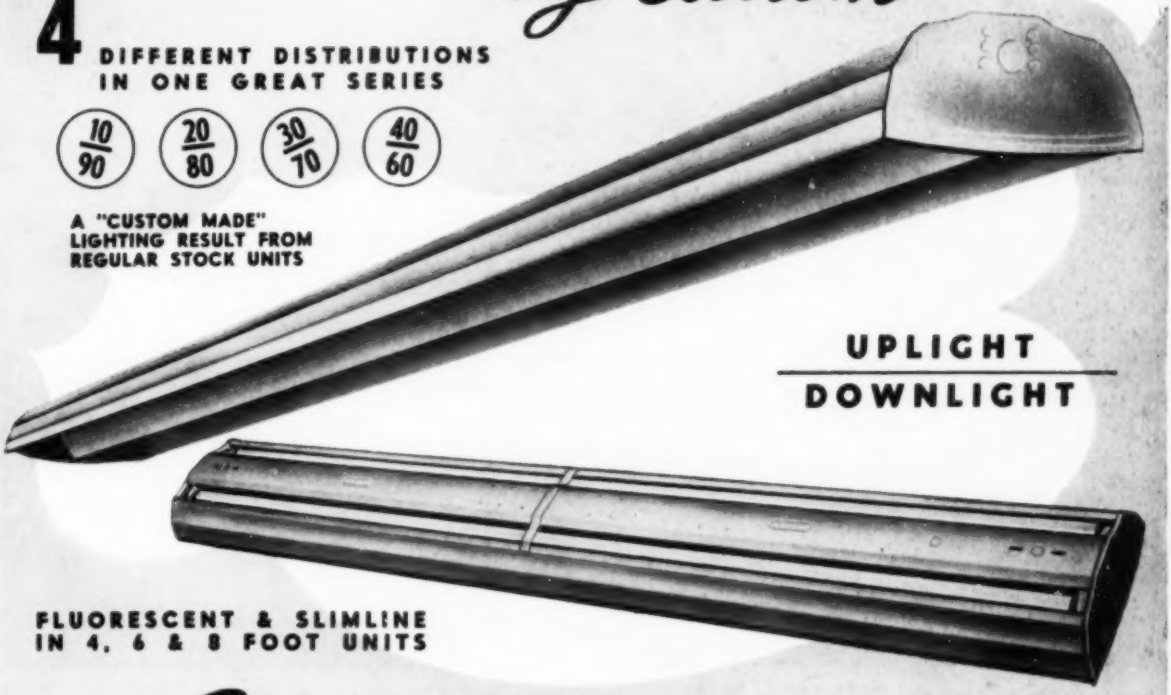
A GREAT NEW LIGHTING DEVELOPMENT

by Eastern

4 DIFFERENT DISTRIBUTIONS IN ONE GREAT SERIES

10/90 · 20/80 · 30/70 · 40/60

A "CUSTOM MADE" LIGHTING RESULT FROM REGULAR STOCK UNITS



UPLIGHT

DOWNLIGHT

FLUORESCENT & SLIMLINE IN 4, 6 & 8 FOOT UNITS

Eastern HEAVY DUTY "IN" SERIES INDUSTRIALS FEATURE:

- 86.5 efficiency louvered
- 90% efficiency unshielded
- 35% cross shielding
- No dark spots
- Simple low cost maintenance
- Dust free design
- Available in 3 louver cutoff
  35° X 25° 35° X 45° 45° X 45°

This extra heavy duty Industrial Unit allows you to offer your customers lighting that is virtually "custom made" to their individual requirements. The combination of 4 different distributions available in this one unit at no extra cost, plus advanced Eastern Engineering and Features make the IN Series the first real outstanding development in industrial lighting fixtures in years.

IN Series units are normally shipped with 40 up — 60 down distribution — other distributions should be specified when ordering.

SEND FOR COMPLETE CATALOG

Eastern ENGINEERED

EASTERN FIXTURE CO.

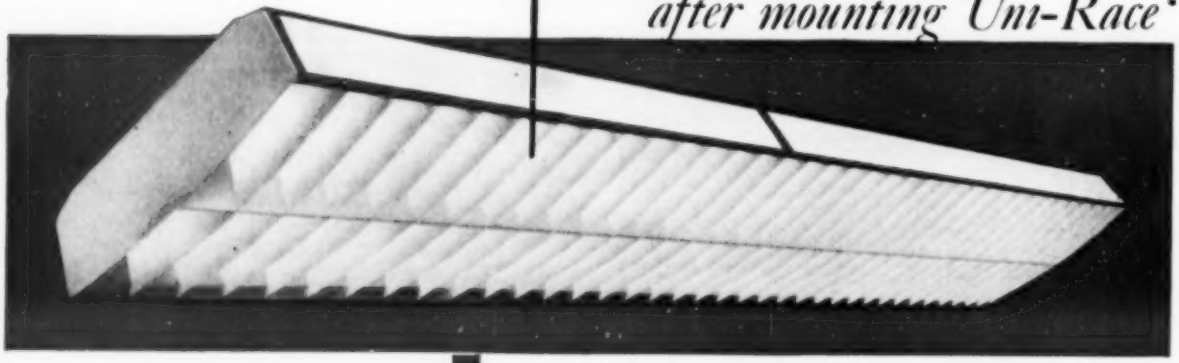
170 VERNON STREET, BOSTON 20, MASSACHUSETTS

YOUR HANDS

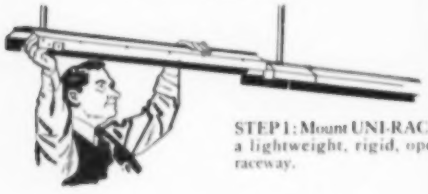
are all you need to install the new Gibson

ortho-77
Reg U. S. Pat. Off. Applied For

after mounting Uni-Race



Patent Applied for



STEP 1: Mount UNI-RACE, a lightweight, rigid, open raceway.

STEP 2: Hang fixture into slots on UNI-RACE spaced for automatic positioning.

STEP 3: PLUG-IN socket makes contact with receptacle in Uni-Race when fixture is closed. Fixture is completely dead when open.

THERE IS NOTHING LIKE IT . . .

So revolutionary in design is the new Gibson ORTHO-77 it is the talk of lighting men everywhere. A special unique raceway (UNI-RACE) provides POSITIVE ALIGNMENT, AUTOMATIC SPACING, FIXED POWER SOURCE, and a RIGID CHANNEL ANCHOR for all ORTHO-77 models. Light in weight, it is readily accessible and easily mounted. A special receptacle permits wire-in in a matter of minutes without tools. Lighting levels can be raised from two to four lite on the same UNI-RACE, or fixtures mounted on a continuous UNI-RACE at spaced intervals can quickly be made continuous later. The fixture is never defaced . . . only the UNI-RACE, a low cost easily replaceable part. The ORTHO-77 is a completely INTEGRATED UNIT built around V-TYPE GIRDER CONSTRUCTION to assure rigidity and permanence of shape. These are just a few of the many features of this phenomenal new concept of design outlined in Bulletin ORT-101. By all means write for it today.

GIBSON *Manufacturing Co.*

1919 PIEDMONT CIRCLE, N. E. • ATLANTA, GEORGIA

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(Continued)

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Secretary — ROY H. KREYSER, Department of Water & Power, 207 So. Broadway, Los Angeles, Calif.

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Chairman — C. F. BALSICK, 2025 Grand, Pueblo, Colo.
Secretary — J. E. PARKER, Southern Colorado Power Co., 115 West 2nd, Pueblo, Colo.

Southwestern Section — Southwestern Region

Chairman — W. T. KIMERY, Dallas Power & Light Co., 1506 Commerce, Dallas, Texas.
Secretary — J. B. DECK, JR., Texas Power & Light Co., P. O. Box 6331, Dallas, Texas.

Tennessee Valley Section—Southern Region

Chairman — J. L. SIMPSON, JR., 500 Exchange Bldg., Nashville, Tenn.
Secretary — WILLIAM RIDLEY, Nashville Electric Service Co., 605 Church, Nashville, Tenn.

Toronto Section — Canadian Region

Chairman — J. D. HARRISON, Holophane Co., Ltd., Queensway at Stephen Drive, Toronto, Ont.
Secretary — G. E. DAVIDSON, 16 Glen Stewart Ave., Toronto, Ont.

Twin City Section — Midwestern Region

Chairman—L. E. JOHNSON, Northern States Power Co., 15 S. Fifth St., Minneapolis, Minn.
Secretary — D. R. SCHWARZ, Westinghouse Electric Corp., 727 Second Ave. N., Minneapolis, Minn.

Twin Ports Chapter — Midwestern Region

Chairman — M. H. PEARSON, 2914 Greysolon Road, Duluth, Minn.
Secretary — O. D. HANKE, General Electric Co., Duluth, Minn.

Utah Chapter — Inter-Mountain Region

Chairman — DALE BROWN, General Electric Co., 200 S. Main, Salt Lake City, Utah.
Secretary — R. M. PIZZA, Utah Power & Light Co., P. O. Box 899, Salt Lake City, Utah.

Vancouver Island Chapter — Pacific Northwest Region

Chairman — P. F. Fletcher, Canadian General Electric Co., Ltd., 711 Broughton, Victoria, B. C.
Secretary — D. A. McDERMOT, British Columbia Electric Co., Ltd., 1501 Douglas St., Victoria, B. C.

Western Michigan Chapter — Great Lakes Region

Chairman — R. C. LYON, Consumers Power Co., Kalamazoo, Mich.
Secretary — L. A. NIEMEYER, Benjamin Electric Mfg. Co., 2708 Jefferson, N. W., Grand Rapids, Mich.

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Chairman — J. F. BUCKLEY, General Electric Co., 901 Genesee Bldg., Buffalo, N. Y.
Secretary — B. H. PLANTE, 112 Hamilton Drive, Snyder, N. Y.

Winnipeg Chapter — Canadian Region

Chairman — E. J. COPLAND, F. D. Bolton Ltd., 401 Avenue Bldg., Winnipeg, Man.
Secretary — D. E. HAIG, Hydro-Electric System, 55 Princess St., Winnipeg, Man.

(Continued from page 15A)

Light Bulbs and Fluorescent Tubes for the Home is a 12-page bulletin with the sub-title "A Reference Guide for Selection and Use." Four pages give details of various types of incandescent and fluorescent sources and the applications for which they are suitable. A companion piece, "Suggestions for Teaching Home Lighting in High School Homemaking Classes," gives lesson subjects, activities and teacher references for such a course. These two lighting information publications are available from Home Lighting Section, Westinghouse Lamp Division, Bloomfield, N. J.

ABOUT PEOPLE

John E. Bock has retired from the General Electric Co. after more than 43 years' service. Mr. Bock entered the company's illuminating laboratory in 1911 and was later put in charge of the photometric testing group in the Lighting and Rectifier Department at Lynn, Mass., where in 1948 he was named supervisor of photometric testing. Mr. Bock is a Fellow of the I.E.S.

The appointment of **J. Stuart Franklin** as supervisor of General Electric Co.'s Lighting and Rectifier Department Photometric Laboratory, Lynn, Mass., has been announced by the department.

The American Society of Civil Engineers announces the election of **Daniel V. Terrell,** of Lexington, Ky., as President. He is Dean of the College of Engineering, University of Kentucky. Dean Terrell, who will succeed Walter L. Huber of San Francisco, will be installed October 21 at the Society's annual meeting in New York City. He will serve one year.

With an expansion of the Westinghouse Lamp Division's sales organization, four new aides have been added to the staff of **Russell E. Ebersole,** general sales manager. **Charles E. Erb** has been named to the newly created post of merchandising manager; **Robert J. Sampson** has been made manager of sales training; **Robert H. Voorhis** will be manager of an expanded market planning department and **Willard L. Adamus** staff assistant to Mr. Voorhis.

Donald L. Millham, General Electric vice president and general manager of the Lamp Division in Cleveland, is one of twelve business leaders named by Secretary of Defense Charles E. Wilson to a special committee to review financial procedures in the Defense Department. The committee, designated the Advisory Committee on Fiscal Organization and Procedures, will seek to work out more effective, simplified, standardized and modern systems of expense control and accountability within the government department. The group will meet periodically to review staff studies and make recommendations.

The appointment of **Ralph C. Nelson** to the position of Purchasing Agent for Benjamin Electric Mfg. Co., Des Plaines, Ill., has been announced. Mr. Nelson succeeds the late **L. W. Kester,** and was formerly assistant purchasing agent.

F. T. Bowditch has been appointed Associate Director of Research of the National Carbon Research Laboratories, Cleveland. Mr. Bowditch has been associated with the company since 1920 and has carried out extensive studies of the carbon arc.

A. A. Hoehling has been named public relations manager of the National Association of Electrical Distributors, with headquarters at 290 Madison Ave., New York City.

Leo Dolkart has joined Commercial Light Co., of Chicago, as Electrical Engineer, with headquarters at the company's offices at 841 W. Washington Blvd.

A. I. Benedict, of the Southern California Section of I.E.S., has successfully undergone surgery for a detached retina of his left eye. Mr. Benedict's many friends will be pleased to hear that "Benny" will retain full vision.

Nate Klein and **John Clugston,** of Klein Associates, Inc., will handle the Abolite line of lamp reflectors in the Chicago area, it has been announced. Before forming Klein Associates, Mr. Klein was general manager of All-Bright Electrical Products Co. Mr. Clugston was formerly associated with Solar Light & Mfg. Co.

Frank L. Synder, vice-president of the Westinghouse Electric Corp., has reassumed management of the firm's Transformer Division at Sharon, Pa.

C. T. Hatcher, Consolidated Edison Co., New York, has been appointed general chairman of the 1954 Winter General Meeting Committee of the American Institute of Electrical Engineers to be held at the Statler Hotel, New York, January 18-22.

W. A. Wallace, formerly with Loftus Engineering Corp., has joined the sales engineering staff of the Keps Electric Co.

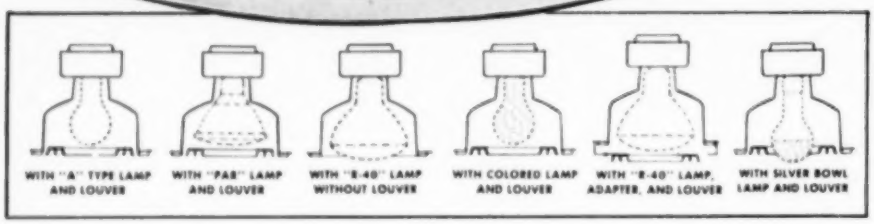
(Continued on page 35A)

DAY-BRITE
DERBY DOWNLIGHTS

No. 80141—with 6¾" diameter Controlens® in removable frame. Recommended for use with 100-watt Type "A" lamp.

® HOLOPHANE CO.

No. R-80140—with removable matt black steel louver. For PAR-38 or Type "A" lamp to 150-watt size. Without louver for R-40 lamp, 150 to 300-watt.


WITH "A" TYPE LAMP AND LOUVER
WITH "PAR" LAMP AND LOUVER
WITH "R-40" LAMP WITHOUT LOUVER
WITH COLORED LAMP AND LOUVER
WITH "R-40" LAMP, ADAPTER, AND LOUVER
WITH SILVER BOWL LAMP AND LOUVER

FOR

Window Display
Marquees
Stores
Lobbies
Soda Fountains
Reception Rooms
Murals
Bathroom Heat Lamp
Restaurants
Canopy Lighting
Escalators
Foyers
Churches
Food Counters
Atmosphere Lighting
Bars
Display Lighting
Greeting Card Racks
Dining Rooms
Kitchens
Rathskellers

Day-Brite Derby units are low-cost, highest quality incandescent downlights. These versatile, easy-to-install recessed spots can take a lighting installation out of the ordinary class—give it sparkle and glamor—without excessive expense. And all Derby Downlights are approved by the Underwriters' Laboratories.

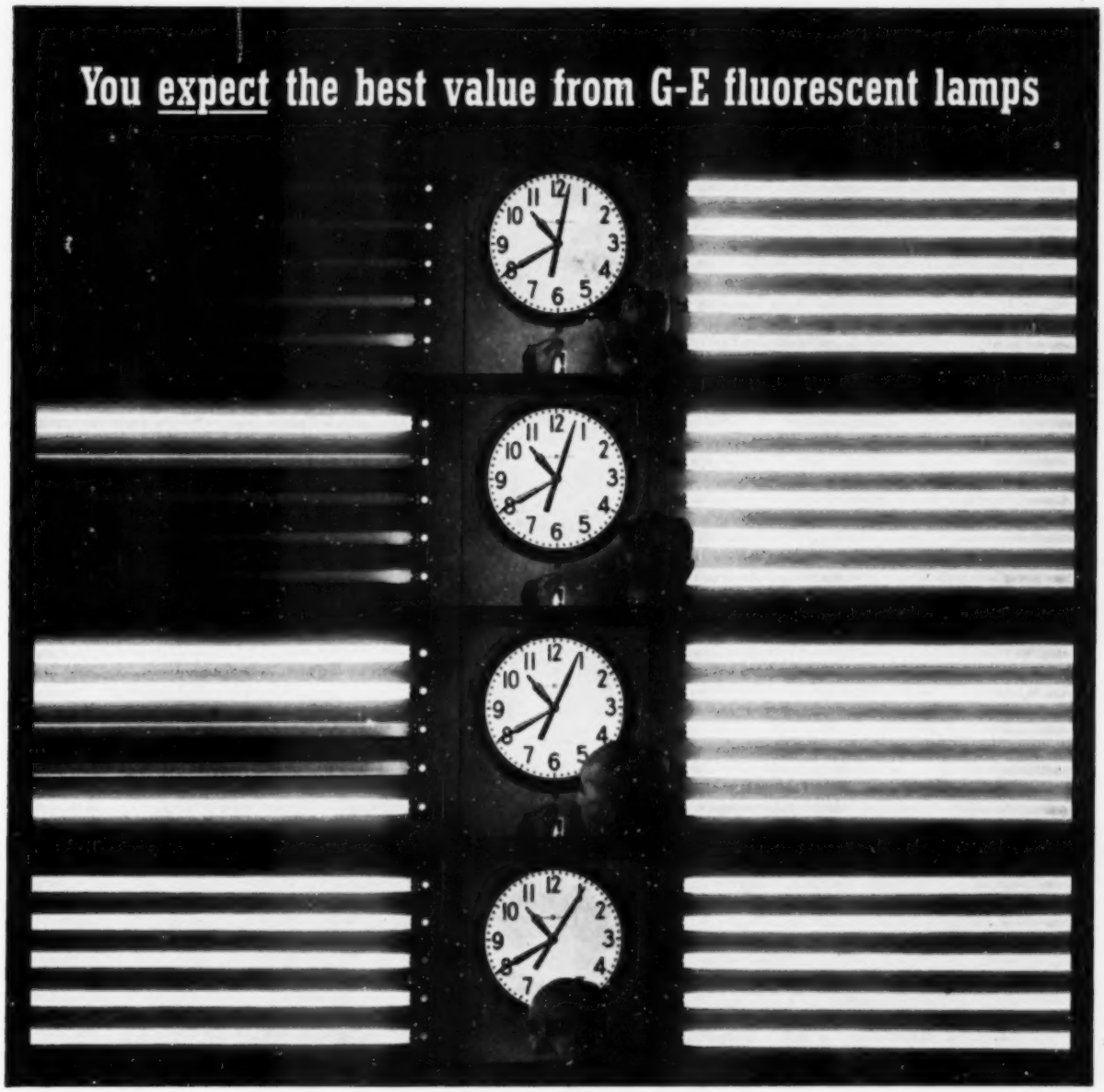
Ask your Day-Brite representative for full information.

"DECIDEDLY BETTER"
DAY-BRITE
Lighting Fixtures

DAY-BRITE LIGHTING, INC., 5432 BULWER AVE., ST. LOUIS 7, MISSOURI
IN CANADA: AMALGAMATED ELECTRIC CORP., LTD. TORONTO 6, ONTARIO

340

You expect the best value from G-E fluorescent lamps



New G-E fluorescent lamp starts quicker, needs no starter

Watch the clock. Above are four unretouched photos taken about one second apart. On the left are regular fluorescent lamps, on the right the new General Electric *Rapid Start* fluorescent lamps. All were started at the same instant.

Within two seconds, all five G-E *Rapid Start* lamps are fully lighted. The regular lamps are only beginning to light.

Two new General Electric developments made the *Rapid Start* lamp possible: a triple coil cathode that holds more starting chemical and a *Rapid Start* ballast that pre-heats the lamp automatically. No starter needed. No wait for pre-heating. Starting is almost instantaneous, maintenance is simpler, cheaper.

Rapid Start lamps and ballasts are now available. You *expect* the best value from G-E fluorescent lamps. Here's one more reason why you can.

For free folder, "Facts About Rapid Start" write General Electric, Dept. 166-1E-10, Nela Park, Cleveland 12, Ohio.

You can put your confidence in —

GENERAL ELECTRIC

SO MUCH MORE UTILITY THAN YOU'D EXPECT . . .

IN A LUMINAIRE OF SUCH RADIANT *Beauty*

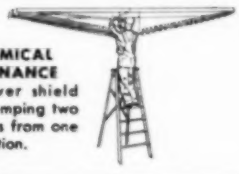
GARCY *Starliner*

OVER 80% EFFICIENCY • 30° x 40° Shielding
. . . yet only 4½" Deep

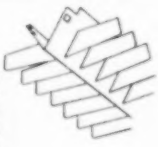
Slim, trim and functional in appearance, the Garcy Starliner lends itself beautifully to contemporary styling. When surface mounted, its shallow contour economically simulates built-in lighting. Yet within its compact design, this luminaire embodies every wanted feature. Side panels of Corning's Alba-lite glass are attractively framed in protective metal rails . . . promote efficient light distribution while contributing to proper brightness control. Garcy's louver design provides 30° x 40° shielding. The Starliner is superbly made . . . note the round edges on end plates and side rails. Economically installed, easily maintained. Available as two-lamp or four-lamp units in 4 ft. or 8 ft. lengths for standard fluorescent, rapid start or slimline lamps. Write for Bulletin L-134.

FAST, LOW-COST INSTALLATION
with Garcy Sliding Clamp Hangers for easy alignment, both vertically and horizontally. Adjustable in height by simply turning stem.

ECONOMICAL MAINTENANCE
Single louver shield permits relamping two 8 ft. fixtures from one ladder position.



STURDY CONSTRUCTION
V-shaped backbone securely holds louver cross-fins under spring tension . . . prevents looseness, rattle or "sing."

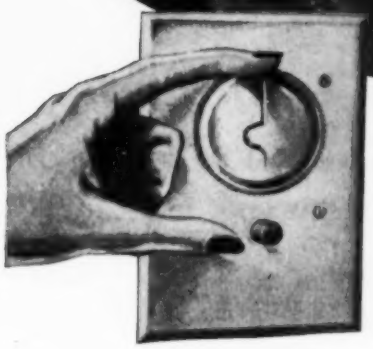


GARCY

GARDEN CITY PLATING & MFG. CO.
1760 N. ASHLAND AVE., CHICAGO 22, ILLINOIS
IN CANADA: GARCY CO. OF CANADA LTD., 191 NIAGARA ST., TORONTO

Controlled Light

. . . a new concept in home lighting



at your fingertips

with the **powerstat**

Wallbox Dimmer

Here is the ultimate in home lighting — a light control designed to replace the ordinary ON-OFF wallswitch . . . to permit the selection of any amount of light from darkness to full brightness. Simply by turning a knob, light can be set to any brightness to suit each seeing task, every activity, all occasions. Operation is smooth and silent. Installation is easy. The powerstat WALLBOX Dimmer is Underwriters' Laboratories Approved. A variety of knobs and faceplates are available to blend with any room decor.

Learn more about CONTROLLED LIGHT, write to:

THE SUPERIOR ELECTRIC CO.
5103 Demers Avenue, Bristol, Conn.

NAME_____

POSITION_____

COMPANY_____

CO. ADDRESS_____

CITY_____ ZONE_____ STATE_____

THE SUPERIOR ELECTRIC CO.
BRISTOL, CONNECTICUT

New G-E clamped core ballast free of enclosure restrictions

Combination 14–15–20-watt unit for home fluorescent fixtures gives you all these advanced design features:

UNDERWRITERS' LABORATORIES have listed this G-E clamped core ballast without any restrictions on the type of fixture which encloses it. This means you can save money by specifying this unit for applications which previously required an encased, compounded unit for U.L. listing.

SMALLER, LIGHTER clamped core design eliminates bulky, compound-filled case, reduces weight and cost of your fixtures.

UNIVERSAL MOUNTING clamp has mounting ears on both side and bottom. Slot-shaped mounting holes permit use of "punched ears" for mounting, allow wider choice in locations of fixture mounting holes.

QUIET OPERATION, so important in home lighting fixtures, results from small size, efficient design, and precision manufacturing techniques.

WIDE APPLICATION helps you simplify your stocking and ordering. This 14–15–20-watt ballast, used singly or in combination, actually replaces up to nine previous G-E ratings for single-, two-, and three-lamp operation.

COMPLETE LINE of G-E clamped core ballasts for small fluorescent lamps includes both enclosed and unenclosed units, combination ratings for 4–6–8-watt and 14–15–20-watt lamp operation. Ballasts for 22-watt circline lamps and 4-watt ozone lamps are also available.

GET FULL INFORMATION about G.E.'s clamped core ballasts. Contact your nearest G-E Apparatus Sales Office or authorized G-E distributor today. Or write for new bulletin GEA-6040 to Section 412-109, General Electric Company, Schenectady 5, N. Y.

GENERAL ELECTRIC

MITCHELL

LODESTAR

4-FOOT MODELS:
Available in 2 or 4 lamp luminaires, in a complete choice of all lamp types.

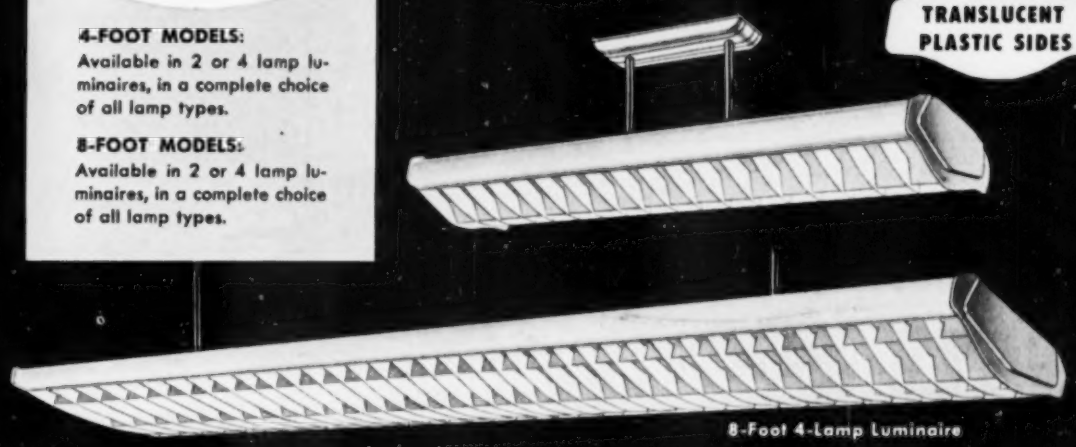
8-FOOT MODELS:
Available in 2 or 4 lamp luminaires, in a complete choice of all lamp types.

the new LOW COST fluorescent luminaire with

UPWARD COMPONENT

TRIM MODERN APPEARANCE

TRANSLUCENT PLASTIC SIDES



8-Foot 4-Lamp Luminaire

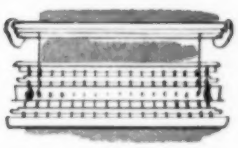
Outstanding lighting advantages and low-cost maintenance

"General Diffuse" type luminaires; approximately half the light goes up to be reflected from ceiling and upper walls for comfortable, glare-free, uniform lighting.

Semi-translucent side panels provide low brightness contrast, creating modern, streamlined appearance. Plastic sides and louver form one easy-to-handle unit.

Sturdy, concealed spring-loaded louver latch instantly releases or engages all-steel louver by snap-in action. Releases with slight pressure of fingers.

MITCHELL engineering achieves remarkable standards of abundant, glare-free illumination in the "LODESTAR" Luminaires. Important lighting advantages are attained by the substantial upward component which provides a "general diffuse" lighting effect. Semi-translucent side panels provide pleasing low brightness contrast. The superior louver design delivers properly shielded illumination to the working area. Smooth styling, unusually low maintenance factor and surprisingly low cost make the new MITCHELL "LODESTAR" Luminaires outstanding values in commercial fluorescent lighting.



Two jack chains suspend entire louver and V-spine assembly from fixture body, making relamping easy and substantially reducing maintenance costs. This feature saves time and money.

New Rapid-Start units offer an unusual advantage: "No starters to replace." Installation of Rapid-Start luminaires slashes maintenance cost by eliminating starter replacement expense.

where quality counts—SPECIFY MITCHELL

MITCHELL MANUFACTURING COMPANY
2525 N. Clybourn Ave., Chicago 14, Illinois
In Canada: Mitchell Mfg. Co., Ltd., 19 Waterman Ave., Toronto

MITCHELL

Mitchell Manufacturing Company, Dept. 3-K
2525 N. Clybourn Ave., Chicago 14, Illinois

Send full data on MITCHELL "Lodestar" Luminaires.

Name.....

Firm.....

Address.....

City.....Zone.....State.....

Protect yourself against

1 HIGH REPLACEMENT COSTS

2 HIGH LIGHT COSTS

3 HIGH MAINTENANCE COSTS

CBM CERTIFIED by ETL

Here's why the initials "CBM" on a Fluorescent Ballast are important to you

Q. What do the initials "CBM" stand for?

A. "CBM" stands for CERTIFIED BALLAST MANUFACTURERS. Nine of the country's leading manufacturers of fluorescent ballasts comprise the CBM group.

Q. What does "CERTIFIED" mean?

A. It means that ballasts carrying this diamond-shaped shield have been built to rigid specifications designated by CERTIFIED BALLAST MANUFACTURERS. It means that Electrical Testing Laboratories, Inc., has periodically tested these ballasts and found they meet or exceed the exact specifications designated by CBM.

Q. What's the need for specifications?

A. Ballasts are the heart of fluorescent lighting. CBM specifications make certain the ballasts provide best possible performance for the lamps they operate.

Q. How do CERTIFIED BALLASTS benefit you?

A. When fluorescent lamps do not perform in accordance with published ratings, low quality or improperly designed ballasts may be the cause. However, most lamp manufacturers waive this possibility if the ballasts involved are CERTIFIED.

The CBM Shield is their assurance that the ballast is delivering proper electrical values to their fluorescent lamps.

CBM specifications protect the public interest because they provide:

FULL LAMP LIFE — **RATED LIGHT OUTPUT**
LONG BALLAST LIFE — **FREEDOM FROM OVERHEATING**
QUIET, TROUBLE-FREE OPERATION

Write for complete information on the types of CERTIFIED CBM BALLASTS available from each participating manufacturer.

Participation in the CERTIFIED CBM BALLAST program is open to any manufacturer who complies with the requirements of CERTIFIED BALLAST MANUFACTURERS.

CERTIFIED BALLAST MANUFACTURERS

Makers of Certified Ballasts for Fluorescent Lighting

2116 KEITH BLDG., CLEVELAND 15, OHIO

(Continued from page 27A)

Towner Buckley, secretary-elect of the Arizona Chapter, I.E.S., has necessitated another election in the Chapter by accepting a position with Crouse-Hinds Co. in San Francisco.

The appointment of **John G. Stanwood** as regional field sales representative in the Baltimore area for the Jefferson Electric Co., of Bellwood, Ill., has been announced. Mr. Stanwood was formerly a salesman with Appleton Electric Co.

ILLUMINATING ENGINEER AND MANUFACTURER'S AGENT

Now representing Chicago manufacturer of fluorescent and slimline equipment. Needs incandescent and mercury vapor equipment to round out agency. Will consider only well designed equipment. Utility and manufacturer's representative background. Well established. Address Box 196, Publications Office, Illuminating Engineering Society, 1860 Broadway, New York 23, N. Y.

SALES ENGINEERS

The Union Metal Manufacturing Company is expanding its sales force and invites applications from experienced engineers in street lighting, construction pile material, equipment sales, or industrial plant material handling sales. Positions leading toward district office or product sales managers.
Prefer applicants having engineering degree or practical experience in any of the above fields. Age 35 to 45 preferred. Applicants interested communicate with The Union Metal Manufacturing Company, attention of D. B. Hanna, Vice President in Charge of Sales, 1432 Maple Avenue, N.E., Canton, Ohio.

DOES PERFORMANCE INFLUENCE YOUR PURCHASING?

• We offer this ballast to quality buyers, entirely on a "performance test" basis. The price is based entirely on our economical cost of producing quality ballasts in large quantities.

ACME ELECTRIC CORPORATION
2910 WATER STREET CUBA, N. Y.
In Canada: ACME ELECTRIC CORP., LTD. • 50 N. Line Rd. • Toronto, Ontario

Acme ACME Electric
TRANSFORMERS

IT'S ABOLITE

FLOODLIGHTING TIME

The greatest selection of styles and types for every purpose.
Get the right floodlights from your wholesaler. Get ABOLITE.

ABOLITE Lighting DIVISION
THE JONES METAL PRODUCTS CO.
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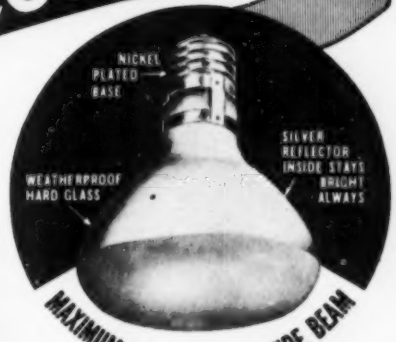
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INDEX TO ADVERTISERS
October 1953

Abolite Lighting Division	35A
Acme Electric Corp.	35A
Benjamin Electric Mfg. Co.	Inside Front Cover
Certified Ballast Manufacturers	34A
Day-Brite Lighting Inc.	28A
Eastern Fixture Co.	25A
Garden City Plating & Mfg. Co.	30A
General Electric Co., Apparatus	12A-13A, 32A
General Electric Co., Lamp	29A
Gibson Manufacturing Co.	26A
Edwin F. Guth Co.	14A
Jefferson Electric Co.	37A
Kopp Glass Inc.	18A
Litecontrol Corp.	9A
Mitchell Manufacturing Co.	33A
R.L.M. Standards Institute	Inside Back Cover
Radiant Lamp Corp.	35A
Smithcraft Lighting Div.	23A
Sola Electric Co.	10A
Starring & Company Inc.	2A
Sunbeam Lighting Co.	36A
Superior Electric Co.	31A
Sylvania Electric Products Inc.	38A
F. W. Wakefield Brass Co.	16A-17A
Westinghouse Electric Corp., Lamps	Back Cover
Westinghouse Electric Corp., Lighting	1A
R. & W. Wiley Inc.	36A

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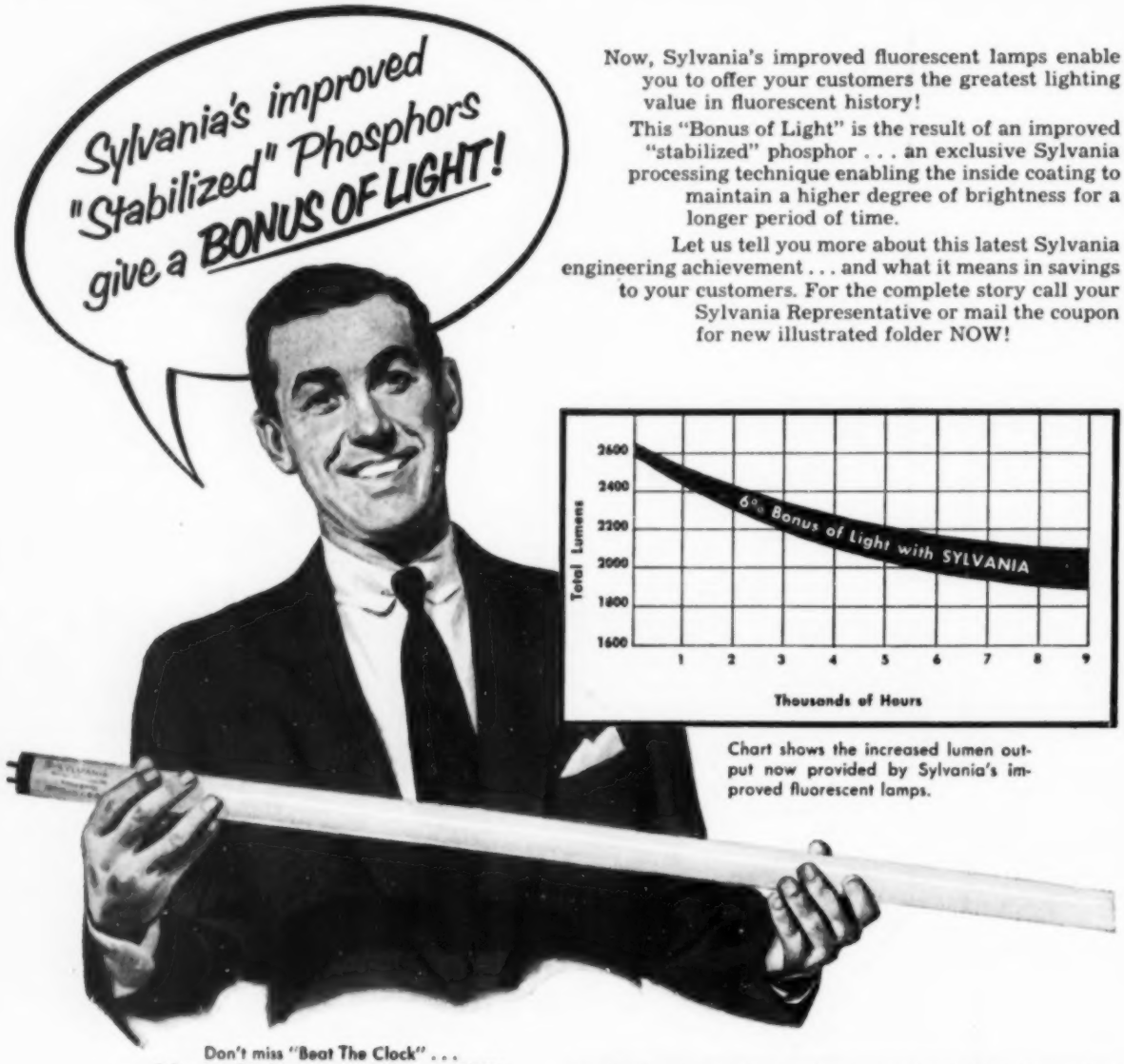

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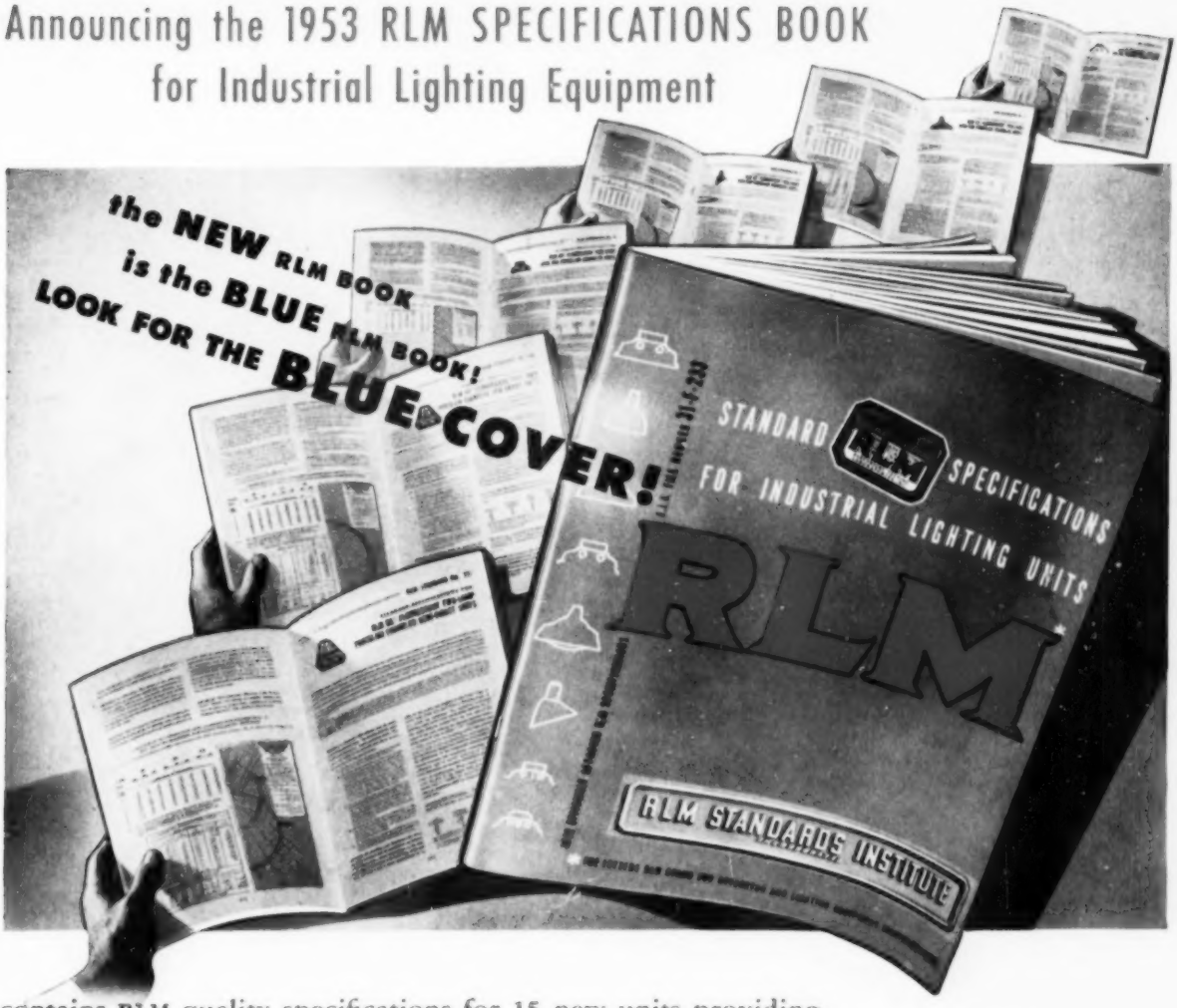

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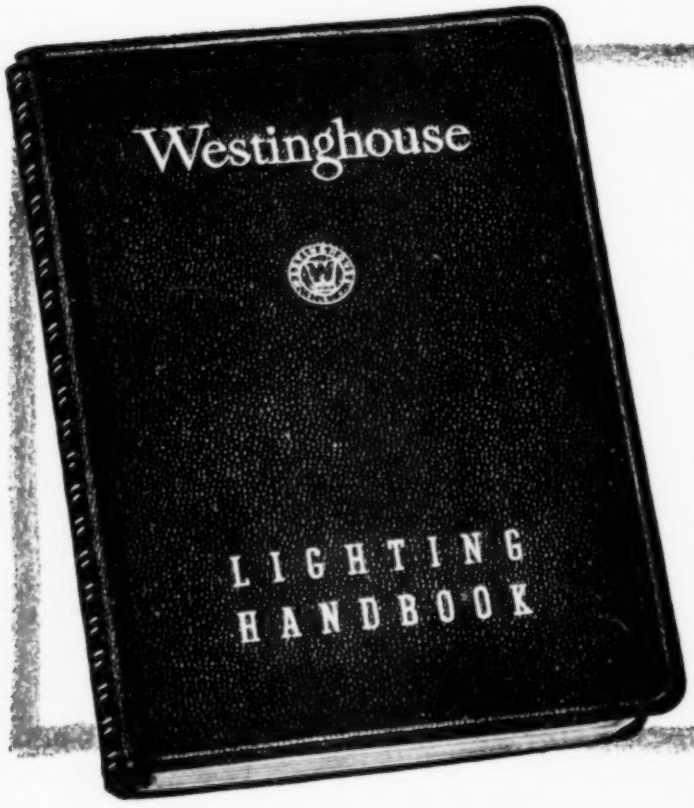

List of Contents

CHAPTER 1	The Eye and Vision
CHAPTER 2	Light—Characteristics and Measurements
CHAPTER 3	Light Sources
CHAPTER 4	Introduction to Lighting Design
CHAPTER 5	Illumination Levels
CHAPTER 6	Interior Lighting Design
CHAPTER 7	Interior Wiring for Lighting
CHAPTER 8	Store, Office, School and Public Building
CHAPTER 9	Industrial Lighting
CHAPTER 10	Architectural Lighting
CHAPTER 11	Floodlighting Design
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